

The Journal of the
**Utah Academy of
Sciences, Arts, & Letters**

Volume 94 • 2017

**Includes selected and refereed articles from the
2017 Annual Conference
held at
Utah Valley University
April 7, 2017**

Editor
Kristin L. Kraus

Copyright 2018, Utah Academy of Sciences, Arts, & Letters.
Copyright reverts to authors after publication. Printed in the United States of America by Brigham Young University Academic Publishing, Provo, Utah. Neither the editors nor the sponsoring organization assumes responsibility for statements of fact or opinion made by the contributors.

ISBN-13: 978-0-9988268-1-3
All Rights Reserved

Board of Editors

Arts: **Angie Banchemo-Kelleher**, Utah Valley University
Biological Science: **Laurie Mauger**, Southern Utah University
Business: **Taowen Le**, Weber State University
Education: **Debora Escalante**, Utah Valley University
Engineering: **Doran Baker**, Utah State University
Exercise Science and Outdoor Recreation: **L Nathan Thomas**,
Salt Lake Community College
Letters—Humanities, Philosophy, Foreign Language:
Jason Goltz, Westminster College
Letters—Language and Literature: **Keith Lawrence**, Brigham
Young University
Physical Sciences: **Chris Monson**, Southern Utah University
Social Science: **Daniel Poole**, Salt Lake Community College
Posters: **R. Steven Turley**, Brigham Young University

2017-2018 Utah Academy of Sciences, Arts, & Letters Officers

President: **H. Laine Berghout**, Weber State University
President-Elect: **Rachel Keller**, Snow College
Past President: **Jonathan Westover**, Utah Valley University
Secretary: **Colleen Boam**, Weber State University
Treasurer: **Karl Israelsen**
Scholarly Communications: **Peter Kraus**, University of Utah
Member at Large: **Spencer Blake**, Salt Lake Community College
Technology Officer: **Rachel Ramsey**, Dixie State University
Institutional Representatives: **Erin O'Brien**, Dixie State
University

Cover Photo: Adriana M. Hall, Donald H. Warner, Brent Hunt.
“Identification and Characterization of a New *Bacillus* Species,”
p. 101.

Utah Academy of Sciences, Arts, and Letters

History: Founded 3 April 1908, the Utah Academy of Sciences was organized "to promote investigations and diffuse knowledge in all areas of science." Beginning in 1923, the Academy started publishing the papers presented in its annual meetings in *Proceedings*. In June 1933 at the annual meeting, the Academy was enlarged to include arts and letters, and the name was changed to the Utah Academy of Sciences, Arts, and Letters. Articles of incorporation and non-profit organization status were accepted by the Academy membership at the spring meeting in April 1959. In 1977, the name of the journal of the Academy was changed from *Proceedings* to *Encyclia*. It became a refereed journal at this time. In the mid 1980s, the scope of the Academy was expanded further to include (1) business, (2) education, (3) engineering, (4) library information and instruction, and (5) health, physical education, and recreation. Beginning with the 1998 issue, the journal became *The Journal of the Utah Academy of Sciences, Arts, and Letters*.

Annual Meeting: The Academy's annual meetings are normally held in the spring on one of the Utah campuses of higher education. The plenary session is called the Tanner Lecture, endowed by Mr. O.C. Tanner in 1986.

Best Paper Awards: The best paper presented in every division is given a cash award, which is presented at the Academy's "Awards Evening" held the following fall.

Distinguished Service Awards: The Academy recognizes outstanding contributions to teaching and scholarship by means of annual Distinguished Service Awards, alternating every other year between disciplines.

Membership: When the Academy was founded in 1908, membership was by nomination, ratified by the Council, and elected by a "three-fourths votes of members present." Today, the Academy's membership is available by application.

Institutional Members: All Utah institutions of higher education are members of the Utah Academy. The Academy appreciates their patronage.

Publication Policy

The *Journal of the Utah Academy of Sciences, Arts, and Letters* publishes works in all of the fields of study encompassed in the Academy's mission. Papers published in *The Journal of the Utah Academy of Sciences, Arts, and Letters* are drawn from papers presented by members in good standing at the annual conference of the Utah Academy. To qualify for publication, the papers must be recommended through a refereeing system.

Presenters are encouraged to publish their paper in *The Journal of the Utah Academy*. *The Journal's* criteria are that a submission is (1) fresh, meaningful scholarly insight on its subject; (2) readable and well written; and (3) of general interest for an academic readership beyond the author's field.

If you wish your paper to be considered for publication in *The Journal*, please submit a Microsoft Word document to the section editor of the appropriate section by the indicated deadline. Contact information for the section editors is available on the Utah Academy's website (www.utahacademy.org).

The Journal of the Utah Academy is a refereed journal. Editorial responses will be forthcoming after the resumption of school the following fall when referees have returned their comments to the division chairs.

Papers should be between ten and twenty double-spaced pages. Detailed instructions to authors are available at http://www.utahacademy.org/Instructions_for_Authors.pdf.

Among the bibliographic services listing at Bowker Serials Bibliographies and The Standard Periodical Direction. Indexing and abstracting services that cite articles in the journal include Arts and Humanities Citation Index, Biosciences Information Services, Current Geographical Publication, Chemical Abstracts, Mathematical Reviews, MLA Biography, Sociological Abstracts, Excerpta Botanica, Social Planning, Policy and Development Abstracts, Language and Language Behavior Abstracts, Index to Scientific Technical Proceedings, and Index to Social Sciences, and Humanities Proceedings.

The Journal of the
**Utah Academy of
Sciences, Arts, & Letters—2017**

AWARDS

Distinguished Service Award	11
Academy Fellow 2018	12
O.C. Tanner Lecture	13
John and Olga Gardner Prize	14
Honorary Member	15
2017 Best Paper Awards	16

ARTICLES

ARTS

Intellectual Theft or Creative License? Copyright Education and the Visual Arts	19
<i>Courtney R. Davis, Utah Valley University</i>	
A Case Against the Institutionalization of the Full Art Process	33
<i>Christopher Lynn, Brigham Young University</i>	
The Arts: A Means to Address the Problems of an Economic Model of Education	51
<i>Kathleen Bunker Sheffield, Brigham Young University and Southern New Hampshire University</i>	

BIOLOGICAL SCIENCES

- Population Model for the Bat Flea *Sternopsylla distincta* (Siphonaptera: Ischnopsyllidae) in Temperate Caves of the Brazilian Free-Tailed Bat *Tadarida brasiliensis* (Mammalia: Chiroptera)** 71

Robert L. Bossard, *Bossard Consulting*

- Kava: An Ethnobotanical Review of *Piper methysticum*** 79

Trevor J. Chamberlain and Olga R. Kopp, *Utah Valley University*

- Identification and Characterization of a New *Bacillus* Species** 101

Adriana M. Hall,¹ Donald H. Warner,¹ and Brent Hunt²
¹*Dixie State University*; ²*Soft Cell Biological Research*

- A Restriction Site (*in silico*) Reevaluation of a Chloroplast Gene Phylogeny for a Common Fern Group: Comparisons with Nucleotide Data and Ordination Analyses** 115

William D. Speer, *Salt Lake Community College*

BUSINESS

- Utah County Housing Trends from 2000-2016: A Quantitative Research Analysis** 137

James C. Brau, Jeremy R. Endicott, Barrett A. Slade, and David N. Wilson, *Brigham Young University*

- The Uncertain Future of LIFO** 151

Jennifer Harrison, Chelsea Dye, and Dara Hoffa, *Westminster College*

- Extracurricular Engagement and Person–Organization Fit through Internalizing Organizational Mission Statements and Values** 167

Ryan Stephenson, Colt Rothlisberger, and Jonathan Westover, *Utah Valley University*

Validating Prior-Learning Assessment Utilizing a Competency-Based Model	195
Jerry A. Van Os, <i>Westminster College</i>	

EDUCATION

Pushing Forward: Finding and Using Meaningful Evidence of Beginning Teacher Competency	217
Mary Sowder, <i>Utah Valley University</i>	

Utilizing Community-Engaged Experiential Learning and Service-Learning Pedagogy to Foster Increased Engaged Educational Experiences at Utah Valley University: A Research Proposal	229
Jonathan H. Westover, <i>Utah Valley University</i>	

ENGINEERING

Application of Orthogonal Frequency Division Multiplexing Techniques to Photographic Media	247
Ethan Albreetsen and Fon Brown, <i>Weber State University</i>	

Simple Strength of Material Experiment To Evaluate The Deflection Of A Beam	257
Jacob Carter and Ali Siahpush, <i>Southern Utah University</i>	

Fundamental Look at the Properties of Copper	267
Casey Cooper, Jacob Carter, Justin Christensen, and Ali S. Siahpush, <i>Southern Utah University</i>	

Effect of Different Potential Combinations on Characteristics of Nanoparticles formed by Dewetting	281
T. McKay Stoker and Nick A. Roberts, <i>Utah State University</i>	

LETTERS—FOREIGN LANGUAGE, HUMANITIES, AND PHILOSOPHY

So Fair a Form: The Role of Gendered Bodies in Medieval Justice Systems	293
Audrey Saxton, <i>Brigham Young University</i>	

The Epiphany of Tuskegee Airman Charles Sumner Stone, Jr.	303
Thomas Clark Terry, <i>Utah State University</i>	

PHYSICAL SCIENCES

Optimization of Broadband Multilayer Mirror Reflectivity via a Genetic Algorithm	317
Michael Greenburg, David D. Allred, and R. Steven Turley, <i>Brigham Young University</i>	

Diastereoselectivity of the Nucleophilic Addition Reaction of the (\pm)-Menthylmagnesium Chloride Grignard Reagent with Phenyl Isocyanate	327
Rebecca L. Maedgen, Myla R. Pereira, and Nathan S. Werner, <i>Southern Utah University</i>	

Effects of Roughness on Reflection of Monochromatic Light	335
Spencer Thevenin and R. Steven Turley, <i>Brigham Young University</i>	

Smoothed Particle Hydrodynamics Simulations of Proto-Planetary Collisions in the Early Solar System	347
Brandon K. Wiggins and Morgan Taylor, <i>Southern Utah University</i>	

SOCIAL SCIENCES

Veterans and the Department of Veterans Affairs	359
Catherine Stoddard, Barrett Bonella, and Corina Segovia-Tadehara, <i>Weber State University</i>	

ABSTRACTS	373
------------------	------------

DISTINGUISHED SERVICE AWARD

The Distinguished Service Award is given to an academic professional for exceptional service to the higher education community in Utah.

Jean B. Cheney

Utah Humanities

Jean Cheney joined the staff of Utah Humanities in 1997 after a career teaching literature and writing in colleges and high schools around the country. In 2005, she founded the Venture Course, a free, college-level humanities course for adults “of modest means who dare to dream,” modeled on the Clemente Course begun in New York City by Earl Shorris in 1995, and awarded a 2014 National Humanities Medal by President Barack Obama. Venture is offered by Utah Humanities in several communities, through partnerships with local colleges and universities. In 2013, under her leadership, Utah Humanities began the high school Clemente Course as a pilot at East High School in Salt Lake City. Clemente is an interdisciplinary humanities course, taught in the high school by college faculty, with the goal of encouraging underserved students to enroll in college. In 2015, Jean was awarded a Fulbright grant to teach literature at Southwestern University in Chongqing, China, and to lecture around China about American environmental writing. She is the lead author of *Hope, Heart, and the Humanities*, a book about the beginning of the Venture Course in Utah, published by the University of Utah Press in 2016. She has a Ph.D. in English from the University of California, Davis, and a M.A.T. from Duke University.

ACADEMY FELLOW 2018

Spencer H. Blake

Salt Lake Community College

Spencer H. Blake is a Professor of Sociology at Salt Lake Community College, where he recently served for five years as the Associate Dean for Psychology & Social Science. In addition to his time at Salt Lake Community College, he taught as an Adjunct Professor at Weber State University and Brigham Young University. He received his MA with Honors from Regis University and his BS from Brigham Young University. He has served the Utah Academy in many capacities, including board service as Member at Large (2001–2004), as chair of the Social Sciences Division (2004–2007), and in the Utah Academy Presidential chain (2007–2012). In 2007, during Spencer's service as President Elect, the Utah Academy celebrated its centennial year, and he was involved in producing the Centennial history of the Academy.

One of Spencer's remarkable gifts that fits in well with the mission of the Utah Academy is his commitment to helping undergraduate students at teaching institutions do their own research and present their results at the Utah Academy. Many found their love of research through Spencer's mentoring over the years.

Spencer's deep commitment to interdisciplinary studies fits naturally with the mission of the Utah Academy, which has long promoted interdisciplinary collaboration. Spencer is a natural collaborator, forming, developing, and supporting collaborative work across disciplines.

Spencer has developed a love for the Intermountain West through his work in the Utah Academy. This developed into a research area for him, resulting in a textbook written with his father, Reed H. Blake. Many of the topics were presented at Utah Academy meetings before finding their way into the textbook.

O.C. TANNER LECTURE

“Enlightenment in Dark Times: Literary Responses to Unsettling Events in Historical Germany”

Scott Abbott

Utah Valley University

Scott Abbott is Professor of Integrated Studies, Humanities, and Philosophy at Utah Valley University. His Ph.D. in German Studies is from Princeton University. His books include *Fictions of Freemasonry: Freemasonry and the German Novel*, two books with Serbian novelist Žarko Radaković—*Repetitions* and *Vampires and A Reasonable Dictionary*, and a book with botanist Sam Rushforth—*Wild Rides and Wildflowers: Philosophy and Botany with Bikes*. A book of fraternal meditations after the death of his brother John of AIDS, *Immortal for Quite Some Time*, was published by the University of Utah Press in 2016. A book about the construction of meaning of barbed wire, written with his wife, historian Lyn Bennett, will appear in the fall of 2017 with Texas A&M University Press. He has translated several works by the contemporary Austrian writer Peter Handke, and with geneticist Daniel Fairbanks he recently published a Darwinized translation of Gregor Mendel’s article “Experiments on Plant Hybrids.”

JOHN & OLGA GARDNER PRIZE

The Gardner Prize is awarded annually for exceptional achievement by an academic professional in Utah.

Margaret Pabst Battin

University of Utah

Margaret Pabst Battin (nicknamed Peggy) is Distinguished Professor of Philosophy and Adjunct Professor of Internal Medicine, Division of Medical Ethics, at the University of Utah. She is a graduate of Bryn Mawr College and holds an M.F.A. in fiction-writing and a Ph.D. in philosophy from the University of California at Irvine. The author of prize-winning short stories, she has authored, co-authored, edited, or co-edited some 20 books, among them a study of philosophical issues in suicide; a scholarly edition of John Donne's *Biathanatos*; *Puzzles About Art*, a volume of case-puzzles in aesthetics; *Ethics in the Sanctuary*, a study of ethical issues in organized religion; and a collection of her essays on end-of-life issues, *The Least Worst Death*. She has also been engaged in research on active euthanasia and assisted suicide in the Netherlands. In 1997, she received the University of Utah's Distinguished Research award, and in 2000, she received the Rosenblatt Prize, the University of Utah's most prestigious award. She was named Distinguished Honors Professor in 2002–03. A second collection of her essays (and fiction) on end-of-life issues is entitled *Ending Life* (Oxford 2005). She is the lead author of two multiauthored projects, *Drugs and Justice* (Oxford, 2008) and *The Patient as Victim and Vector: Ethics and Infectious Disease* (Oxford, 2009). She is the general editor of *The Ethics of Suicide: Historical Sources* (Oxford 2015), an extensive sourcebook coupled with an online Digital Archive hosted by the academic library at the University of Utah <ethicsof suicide.lib.utah.edu>. She is currently completing *Sex & Consequences*, a book on large-scale reproductive issues, including world population growth and reproductive rights. She is also at work on a set of novel considerations about urban design in the light of ecological, environmental, resource-use, and social issues, called "How to Live in an Italian Hill Town and Still Get to Walmart." She has been named one of the "Mothers of Bioethics."

HONORARY MEMBER 2018

Robert (Archie) Archuleta

Robert “Archie” Archuleta stands as a lifelong advocate for education and community engagement in all its forms. Born in Grand Junction, Colorado, Archie worked his way toward a BA in Social Sciences from Idaho State College and completed his postgraduate work at the University of Utah in education. He taught elementary school in the Salt Lake City School District from 1953 through 1987 and was an Adjunct Professor of Sociology at Salt Lake Community College. Upon retiring, Archie continued his commitment to community and civic engagement, working to carve out spaces for voices throughout Utah. He has been an active member of numerous organizations devoted to activism and advocacy. He is currently the President of the Board of the Utah Coalition of La Raza, as well as a member of numerous boards such as the Utah Humanities Council, Centro Civico Mexicano, Concerned Citizens Committee, and many others. His list of awards is as voluminous as his service, including the Quixote Lifetime Achievement Award from the Utah Hispanic Chamber of Commerce and the Charles E. Bennet Humanitarian and Civil Rights Award from the Utah Education Association. All of these achievements speak clearly about his contribution to education. Yet what repeatedly emerged upon Archie’s selection for the Utah Academy’s Honorary Member Award was his approach in achieving these remarkable successes. Every person who spoke of Archie emphasized his caring, thoughtful, and devoted approach to serving all communities and peoples, but particularly those who are underrepresented and often unheard. He is recognized throughout Utah as a well-respected and admired advocate. It is our honor to join with many others to thank and commend Archie for his outstanding contribution by awarding him the Utah Academy of Sciences, Arts, and Letters Honorary Member Award.

2017 BEST PAPER AWARDS

Art

Intellectual Theft or Creative License? Copyright Education & the Visual Arts

Courtney R. Davis
Utah Valley University

Biological Sciences

Identification and Characterization of a New *Bacillus* Species

Adriana M. Christensen, Donald H. Warner, Brent Hunt
Dixie State University and Soft Cell Biological Research

Business

Utah County Housing Trends from 2000–2016: A Quantitative Research Analysis

James C. Brau, Jeremy R. Endicott, Barrett A. Slade, David N. Wilson
Brigham Young University

Education

Pushing Forward: Finding and Using Meaningful Evidence of Beginning Teacher Competency

Mary Sowder
Utah State University

Engineering

Effect of Different Potential Combinations on Characteristics of Nanoparticles Formed by Dewetting

T. McKay Stoker, Nick Roberts
Utah State University

Letters: Humanities, Philosophy, and Foreign Language

**So Fair a Form: The Role of Gendered Bodies in
Medieval Justice Systems**

Audrey Saxton

Brigham Young University

Physical Sciences

**Diastereoselectivity of the Nucleophilic Addition
Reaction of the (\pm)-Menthylmagnesium Chloride
Grignard Reagent with Pheyl Isocyanate**

Rebecca L. Maedgen, Myla R. Pereira, Nathan S. Werner

Southern Utah University

Intellectual Theft or Creative License? Copyright Education and the Visual Arts

Courtney R. Davis

Utah Valley University

Abstract

This paper explores the ethical responsibility of teaching students of the visual arts about the importance of copyright protections and restrictions. This responsibility stems from the historical purpose of copyright, as well as contemporary applications. Although the parameters and protections of intellectual property law have been debated for centuries, contemporary technology has exacerbated the moral and ethical need to educate students about the rights and restrictions associated with the use of creative content. Our highly visual, content-saturated e-world has produced several alarming trends, such as the mistaken assumption that online content is different from and therefore not protected by the same copyright laws as tangible, printed material, as well as the “who will ever know?” or “catch me if you can” approaches to content appropriation. To prepare students for the arts profession, the author proposes four moral obligations with respect to arts educators: 1) raising awareness about copyright protections and restrictions; 2) disseminating accurate information; 3) helping students understand when fair use is appropriate; and 4) practicing ethical behavior.

The motivating principle behind copyright protection is to promote progress in the arts by granting creators certain exclusive rights in their works for a limited period of time.¹ This form of intellectual property law, which protects original works of authorship fixed in a tangible form, provides an economic incentive to create new works, which, in turn, may contribute to the intellectual enrichment of the public. Copyright law grants the creator the exclusive rights to reproduce, distribute, display, and create derivative works or to permit others to engage in the same actions. Without permission from the copyright holder, the use or appropriation of a copyrighted work is considered infringement unless it falls under an exception, such as fair use.²

The fair use doctrine, a mediator between property rights and artistic expression, allows for the unlicensed use of protected works in certain circumstances. However, this exception has been increasingly viewed as a blanket escape clause, particularly within the context of online content, which has created a new generation of users who seem to believe that just because an image, sound bite, or film clip appears on the Internet, it is free of copyright protection. Many invert the judicious “assume it’s protected” rule³ to assume that online content is in the public domain by virtue of its electronic format. The misunderstanding of copyright law as applied to online content presents significant moral and ethical concerns that not only threaten to erode the purpose of copyright, but could threaten the economic and intellectual value of creative work in many circumstances.⁴

The purpose of this paper is to demonstrate the ethical responsibility to teach about the importance of copyright law in visual arts education. This responsibility stems from the historical purpose of

¹ U.S. Const. art. I, § 8.

² To qualify as fair use, a new work generally must alter the original with “new expression, meaning, or message.” *Campbell v. Acuff-Rose Music, Inc.*, 510 U.S. 569 (1994): 579.

³ The Stanford University Libraries Copyright & Fair Use resources advocate this assumption: “A work is not in the public domain simply because it has been posted on the Internet (a popular fallacy) or because it lacks a copyright notice (another myth).” Stanford University Libraries, “Websites: Five Ways to Stay Out of Trouble,” *Copyright & Fair Use*, accessed on July 15, 2016. <http://fairuse.stanford.edu/overview/website-permissions/websites/>

⁴ While the motivating principles behind copyright protection are to stimulate progress and for the intellectual enrichment of the public, some argue that copyright protection has the opposite effect—that copyright law hampers rather than promotes progress by creating arbitrary limitations. Indeed, for centuries, artists have incorporated influences from the work of others, be it stylistically, compositionally, or in relationship to specific content or themes. Our cut-and-paste world of mechanical replication and digital appropriation has introduced a new set of challenges with respect to these themes, including what constitutes fair use, or even, how fair the concept of fair use actually is.

copyright, as well as contemporary applications and (mis)uses. Copyright ethics has been at the forefront of several recent high-profile appropriation cases, which have drawn the art community's attention to the legal boundaries and moral implications of copyright protection. Because students of the arts often struggle with understanding the basic parameters of copyright law, I propose four moral duties with respect to arts education and intellectual property.

The History of Copyright: A Moral Perspective

The need for copyright protection is a product of the age of reproducibility, largely stemming from the invention of the printing press. The ability to reproduce printed material beginning in the 15th century drastically transformed the dissemination of knowledge, which introduced a system of competing claims among authors/creators, publishers/producers, sellers, and finally, consumers. Creative content itself was not immune from these complications, such as when governing bodies sought to censor works deemed inappropriate, heretical, or seditious. For example, in England, printers were granted a monopoly on printing through the Licensing of the Press Act of 1662. The Act gave the royally chartered Worshipful Company of Stationers, better known as the Stationer's Company, the exclusive right to monitor printed material and, essentially, to regulate the printing industry. Far from protecting the rights of authors, the Licensing and Press Act largely restricted printed material. One 19th-century critic went so far as to proclaim, "It will remain the task of some historian... to show how boundless was the mischief, spreading over generations, that was done by the exercise of this monopoly."⁵ This critic, who chose to remain anonymous because of the politically charged nature of his/her claims, argued that this intellectual control was for no other purpose than economic advantage and that it functioned "to spread superstition and perpetuate ignorance, to hinder and repress the march of science, and to lead the public mind back to the darkness of the Middle Ages."⁶

The Licensing of the Press Act lapsed in 1695, opening the door for a more enlightened view of intellectual property. The British Statute of Anne, also known as the Copyright Act of 1709, was the first statute to provide legal protections for copyrights. The statute placed the power to make copies in the hands of authors, rather than publishers.

⁵ *Entered at Stationer's Hall* (London: M. Thomas, Franklin Press, 1871), 13. Available at https://books.google.com/books?id=3w8HAAAAQAAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

⁶ *Ibid.*

The formal title of the statute succinctly expresses the balancing of competing rights: “An Act for the Encouragement of Learning, by Vesting the Copies of Printed Books in the Authors or Purchasers of Copies, during the Times therein mentioned.” The preamble frames the purpose of this revolutionary act, referencing the previous practice of printers and booksellers to print or reprint works without the consent of authors “to their very great Detriment, and too often to the Ruin of them and their Families.”⁷ Although the statute was limited in scope, its underlying principles dramatically impacted the concept of authorship and the operation of the book industry. The Statute of Anne would also impact branches of the visual arts: The protection initially afforded only to authors was extended to printmakers in the Engraving Copyright Act of 1734, largely because of the efforts of William Hogarth (hence the law often being referred to as “Hogarth’s Act”).

This new way of approaching intellectual property was not confined to Great Britain alone. Article 1, Section 8 of the United States Constitution empowers Congress “[t]o promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries.” The parameters of copyright law and protection would expand in the United States over the course of the 19th- and 20th centuries, far outstripping the original limitation to maps, charts, and books to protect works of visual art, movies, songs, films, computer software, and architecture, among other categories.

Modern copyright law has been described as “a system seeking an appropriate legal balance between the rights of authors and publishers on one hand and the rights of users and consumers on the other.”⁸ In practical terms, if a creative work is not sufficiently protected, the incentive to create could be greatly mitigated, because of lack of economic value. In this connection, Mark Alfino, a leading scholar on the topic, has asserted: “the ethical values which underlie copyright law emerge alongside the development of economic markets for intellectual labor,” which include the shift from the traditional system of patronage as well as the emergence of widespread literacy among the public.⁹ While not all artists create works solely for the marketplace, and while the creative spirit is nourished by more than economic compensation

⁷ 8 Anne, c. 19 (1710).

⁸ Howard B. Abrams, “Originality and Creativity in Copyright Law,” *Law & Contemporary Problems* 55 (1992), 1.

⁹ Mark Alfino, “Intellectual Property and Copyright Ethics,” *Business & Professional Ethics Journal* 10, no. 2 (1991), 92.

alone, these factors are highly significant when considering the profession of artistic production.

Appropriation Art and the Ethical Conundrum

Today, most people are aware of the general principles of copyright law, if only from copyright warnings on films and digital downloads or from reading about the occasional infringement case in the entertainment news. But a cursory familiarity with the term *copyright* is not enough for those working within the arts. From students to professionals, far too many practitioners are unfamiliar with the boundaries, rights, and remedies of copyright. For example, it is not uncommon for professional artists to admit (after someone has copied their work) that they never registered their work with the U.S. Copyright Office and that they were unaware they needed to register their copyright to bring a claim in federal court (or, that is, any court). Although variation exists, it is typically rare for professors to focus heavily on intellectual property law within the higher education studio arts context. Copyright might be mentioned, but students are often unaware of their rights, remedies, and restrictions, which leads to artistic professionals unprepared to navigate the intellectual property arena. Indeed, the New York City Bar Copyright Myths Committee recently published, “Top Ten Copyright Myths,” which reveal the mystifications and misunderstandings common in copyright use, such as, “I can use up to 10% of a copyrighted work without permission, or four bars of a song, because that would be a ‘fair use’ and not an infringement.”¹⁰

Rather than using ethics as a guiding tool for appropriation art, some artists are tempted to employ the highly unethical “catch me if you can” or “unless/until I’m caught” approaches. Unfortunately, this cavalier attitude has been intensified by a recent string of glitzy, high-profile copyright infringement cases that have brought fame to both the plaintiffs and the defendants. Today, it is not unheard of for some artists to admit they intentionally create work with potential copyright implications in the hope of being caught. Why would anyone risk being sued in federal court for copyright infringement? The answer is simple: because of the potential notoriety and fame. In other words, to put one’s name on the contemporary art map.

Since the 1980s, certain appropriation artists have created the appearance that copyright infringement is the royal road to notoriety. Ap-

¹⁰ New York City Bar Association Committee on Copyright and Literary Property, *Top Ten Copyright Myths* (New York: 2015), 15. <http://www2.nycbar.org/pdf/report/uploads/20072995-CopyrightMythsCOPLIT11.17.15.pdf>

appropriation artists intentionally borrow or copy from preexisting sources with little or no transformation, often for the purpose of drawing attention to such themes as the loss of originality, the pervasiveness of the media, and the search for meaning in popular culture. Common techniques for visual appropriation artists include photocopying, collaging, quoting, copying, projecting, and re-photographing from original sources. American photographer and painter Richard Prince (b. 1949), for example, rose to fame in the 1980s by re-photographing Marlboro cigarette advertisements for his famous “Cowboys” series. Prince has since been sued numerous times over copyright infringement, although the case that made headlines in recent years is *Cariou v. Prince* (2013).

The hotly contested suit began after Richard Prince altered and incorporated photographic imagery taken by Patrick Cariou and published in the latter’s book, *Yes Rasta* (2000). Cariou brought suit against both Richard Prince and New York’s Gagosian Gallery, which exhibited the works and published an exhibition catalog.¹¹ Although the defendants argued fair use, the United States District Court for the Southern District of New York entered a permanent injunction and “compelled the defendants to deliver to Cariou all infringing works that had not yet been sold, for him to destroy, sell or otherwise dispose of.”¹² The decision caused an uproar in the contemporary arts community, partially because of the implication of the Gagosian Gallery. However, upon appeal, the United States Court of Appeals for the Second Circuit overturned the lower court’s decision.¹³

The Second Circuit Court’s decision perhaps indicates that courts are becoming more flexible when considering issues of appropriation, transformation, and originality, moving away from the trend of typically finding for the plaintiff (or the original creator). Some have criticized the holding, arguing that it exonerates appropriation artists. Others have commented on the questions that still remain. For example, in an interview with *Art in America* magazine, New York attorney Sergio Muñoz Sarmiento asserted, “The judges at the Second Circuit court decided that the case would hinge on whether a reasonable observer would find Prince’s works to have been transformative, and thus protected under fair use law. The question remains, what is a ‘reasonable

¹¹ *Cariou v. Prince*, 784 F.Supp.2d 337 (SDNY 2011).

¹² *Ibid.*

¹³ The court reversed in part, vacated in part, and remanded the case for further proceedings consistent with the opinion. *Cariou v. Prince*, 714 F.3d 694 (2013), 23.

observer'?"¹⁴ Although Amy Goldrich, of New York's Cahill Partners, noted, "I can see how those whose work may be sources for appropriation will likely be disappointed by this outcome, but there's a lot more clarity now on how fair use applies. That additional clarity for artists is a good thing."¹⁵

Incidentally, Richard Prince is again facing a lawsuit over taking other individuals' Instagram photos, making extremely small modifications, exhibiting, and then selling them for as much as \$90,000.¹⁶ When this suit concludes, another will likely follow, as litigation controversy plays strongly into the work of the artist. But what moral and ethical implications do these types of cases have on the creation and consumption of art? How do we teach students of the arts to uphold the values of copyright law when blue-chip contemporary artists garner fame and fortune from seemingly doing the opposite, or when appropriation has become a ubiquitous staple of contemporary art practices? How can we teach those working outside of the arts to respect intellectual property in our "cut-and-paste" world of digital shape-shifting? Even though the doctrine of fair use involves the rule of law, the answer to these questions must incorporate the application of moral judgment.

Fair Use and Ethical Balancing

Ethical and moral judgment become imperative when faced with decisions that leave room for varying interpretation, such as the fair use doctrine. Far from a bright line or clearly defined rule, the fair use test relies upon balancing. The standard four-factor test under 17 U.S.C. § 107 stipulates that:

[T]he fair use of a copyrighted work ... for purposes such as criticism, comment, news reporting, teaching (including multiple copies for classroom use), scholarship, or research, is not an infringement of copyright. In determining whether the use made of a work in any particular case is a fair use the factors to be considered shall include—

¹⁴ Brian Boucher, "Landmark Copyright Lawsuit Cariou v. Prince Is Settled," *Art in America*, March 18, 2014, <http://www.artinamericamagazine.com/news-features/news/landmark-copyright-lawsuit-cariou-v-prince-is-settled/>

¹⁵ *Ibid.*

¹⁶ See Mahita Gajanan, "Controversial artist Richard Prince sued for copyright infringement," *The Guardian*, January 4, 2016, <https://www.theguardian.com/artanddesign/2016/jan/04/richard-prince-sued-copyright-infringement-rastafarian-instagram>

- (1) the purpose and character of the use, including whether such use is of a commercial nature or is for nonprofit educational purposes;
- (2) the nature of the copyrighted work;
- (3) the amount and substantiality of the portion used in relation to the copyrighted work as a whole; and
- (4) the effect of the use upon the potential market for or value of the copyrighted work.

Terms such as *purpose*, *character*, *nature*, and *substantiality* clearly require a balancing of facts. Herein lies the frustration with copyright law for both lawyers and creators—there is no way of knowing for certain how a court might interpret a particular set of facts. For example, many disagree with the holding of one of the most legendary fair use cases, *Rogers v. Koons* (1992), in which renowned artist Jeff Koons appropriated a photographic image taken by Art Rogers of a man and woman with their arms laden with puppies.¹⁷ Even though Koons transformed the black-and-white postcard image into a painted wood sculpture more than five feet in length and made other artistic modifications, the court rejected Koon’s argument of fair use by parody. They asserted that Koons’s sculpture was a copy of Roger’s photograph, that it did not fall under the domain of fair use, and that Rogers was entitled to a large monetary settlement from Koons. Many have disagreed with this holding, including the author of this paper, because of the seemingly transformative nature of Koon’s work, particularly with relationship to medium, size, color palette, and possible interpretation.

But in the more recent case, *Cariou v. Prince*, discussed above, Richard Prince’s appropriation of Patrick Cariou’s photographs into collage works *was* considered fair use. These types of seemingly disparate holdings, which have caused confusion and even consternation, illustrate the balancing that courts engage in when evaluating copyright infringement and the fair use defense. Just as artworks involve subjective, value-based judgments, so does the theory of fair use.

Given the complexity of intellectual property law, as well as the variation in its application, the temptation for some to ignore the potential legal ramifications of their work is perhaps understandable. After

¹⁷ *Rogers v. Koons*, 960 F.2d 301 (2d Cir. 1992).

all, Richard Prince and Jeff Koons are contemporary art rock stars, and their high-profile copyright entanglements have only added to their notoriety. At the same time, art institutions and art historians have reinforced the practice of appropriation as a contemporary technique. Tate Online offers this definition: “Appropriation in art and art history refers to the practice of artists using pre-existing objects or images in their art with little transformation of the original... Appropriation has been used extensively by artists since the 1980s.”¹⁸ Yet, while Tate provides examples of appropriation art, from Picasso and Duchamp to Sherrie Levine and Jeff Koons, no mention is made of the potential copyright issues associated with these practices. Given the ubiquity of appropriation art in the contemporary age, it is not surprising that art students may be confused as to the applicability of intellectual property law.

Adding an additional layer of complexity is the shifting nature of artistic practices and techniques. When the current Copyright Act of 1976 was enacted, legislators could not have foreseen many practices common to contemporary art today, particularly with respect to digital art and new media.¹⁹ Indeed, critics of the American copyright system have emphasized the limitations of copyright with respect to digital technology. Some have argued that copyright law restricts creativity, that it imposes a monopoly on information, and that certain creative works should be in the public domain to be used to benefit the populace. Indeed, one might wonder what the future holds for the visual arts with respect to intellectual property, particularly as artworks stray from the traditional mode of being “fixed” in a “tangible medium,” a requirement for copyright protection. These points are not without merit; but whether the copyright system should be amended or even replaced is perhaps beyond the scope of this paper. The author does not suggest that copyright should be without boundaries or the opposite, that the fair use doctrine should be curtailed. However, copyright protection is a valuable right within the arts profession, one that plays a strong role in the development and advancement of artistic careers. Because of this, creators have a strong incentive to protect their work, be it for reasons related to moral rights, intellectual ownership, or economics.

Indeed, while the creation of art for art’s sake can be a powerful motivating force, earning a living is an equally powerful force. After all, even the great masters had to pay their bills; Michelangelo did not

¹⁸ Tate Museum, “Appropriation.” *Tate*. <http://www.tate.org.uk/art/art-terms/a/appropriation>

¹⁹ Although it should be noted that amendments and case law help to supplement and update the Copyright Act.

paint the Sistine Ceiling as a gratuitous act of religious service, he was well compensated for his labor. Even while many Renaissance painters enjoyed the benefits of deep-pocketed patrons like the Catholic Pope or the Medici, those working on the open market began to seek ways of protecting their work in order to safeguard their livelihood. For example, Northern Renaissance artist Albrecht Dürer included identifying names and marks in his engravings, in an attempt to prevent copyists from recreating his prints. As noted above, the passage of the Engraving Copyright Act of 1734 was largely due to the efforts of English artist William Hogarth. As these examples would attest, intellectual property rights relate not only to economics, but also to artistic integrity. The arts are an academic discipline, with specific theories and terminologies, modes of practice and professional conduct. The appropriation of creative works outside of fair use without permission is a form of plagiarism, an act of fraud, or even of theft—a theft of ideas, of time, and of artistic process.

Given these reasons supporting the importance of intellectual property law, as well as the challenges of understanding copyright and fair use, what then is the responsibility of educators? Assuming having an attorney on retainer as a consultant is likely outside the reach of most departmental budgets, what, then, are the ethical obligations with regard to understanding copyright law and fair use? I propose four moral duties with respect to arts education:

First, to raise awareness: For many, the idea of copyright or intellectual property law is a nebulous, unfamiliar concept. Teachers within the arts have a moral duty to raise awareness of these topics in the classroom by being conversant with terminology and applications. Part of this duty is to help students know where to access more information, as well as to help students understand their own responsibilities as producers of creative content.

Second, to disseminate accurate information: It is not enough simply to toss out terms or refer to random readings that cause more harm than good. Teachers have a moral duty to disseminate accurate information and to help students navigate the legal-artistic domain, even if this requires bringing oneself up to speed through self-study. Teachers should educate themselves to avoid spreading misinformation, such as the popular myth that one needs only change an artwork by a certain percentage to avoid a claim of copyright infringement. Providing accessible sources of accurate information (as well as acknowledging the need to stay current on intellectual property topics) is the

second step in a moral approach to intellectual property law in arts education.

Third, to help students understand when fair use is appropriate: Although copyright law provides important protections and restrictions related to the use of content, it is not absolute or without exception. In addition to the public domain, students should be familiar with the guidelines of fair use and when appropriation is permissible. In this connection, the College Art Association has produced *The Code of Best Practices in Fair Use for the Visual Arts* (2015), which provides guidelines for writing and teaching about art, as well as for producing and displaying art in museums.²⁰ *The Code* asserts that members of the artistic community “may self-censor” with regard to fair use “due to confusion, doubt, and misinformation about fair use, leading them to over-rely on permissions... Doing so jeopardizes their ability to realize their own full potential, as well as that of the visual arts community as a whole.”²¹ Thus, to prepare students to engage fully in the artistic profession, educators should help students to understand both the *parameters* as well as the *possibilities* of fair use.

Fourth, to practice ethical behavior: Students not only emulate their teachers, they also rely upon them to set professional standards. If a professor extols the value of copyright law and the ethical treatment of intellectual property but does not apply these principles in his or her own professional work, not only does the professor lose credibility, students may follow suit, feeling that copyright law is something only to consider only theoretically, but not in practice.²²

Because the legal domain does not provide a simple, bright line rule for fair use, the application of ethical principles is more vital than ever to the moral and responsible use of creative work. Most infringement issues are not high-profile legal cases covered by the press and splashed across the pages of arts magazines. They are often quiet and easy to overlook. Because of the use of social media and websites to promote artworks, professional artists and students alike are experiencing a marked upsurge in intellectual theft. Artists must promote their

²⁰ College Art Association, *The Code of Best Practices in Fair Use for the Visual Arts* (2015). <http://www.collegeart.org/pdf/fair-use/best-practices-fair-use-visual-arts.pdf>

²¹ *Ibid.* at 6.

²² In fact, students can easily use the Copyright Office’s online searchable registry to discover whether or not their professors have ever registered their work. See: <http://www.copyright.gov/records/>

work online to gain a strong presence in the market, but the very act of posting images opens them up to visual pilferers, some of whom might not even be aware that their appropriations far outstrip the legal or ethical boundaries of fair use. Images are appropriated for t-shirt designs, unauthorized photographs are used in publicity campaigns, scans of artworks are even offered for sale as fine art prints. Where does it stop? Part of the solution exists in raising awareness, disseminating accurate information, and raising the ethical bar, one issue and one case at a time.

WORKS CITED

Abrams, Howard B. "Originality and Creativity in Copyright Law," *Law & Contemporary Problems* 55 (1992): 3-44.

Alfino, Mark. "Intellectual Property and Copyright Ethics," *Business & Professional Ethics Journal* 10, no. 2 (1991): 85-109.

Boucher, Brian. "Landmark Copyright Lawsuit Cariou v. Prince is Settled," *Art in America*, March 18, 2014, <http://www.artinamericamagazine.com/news-features/news/landmark-copyright-lawsuit-cariou-v-prince-is-settled/>.

Campbell v. Acuff-Rose Music, Inc., 510 U.S. 569 (1994).

Cariou v. Prince, 784 F.Supp.2d 337 (SDNY 2011).

Cariou v. Prince, 714 F.3d 694 (2013).

College Art Association. *The Code of Best Practices in Fair Use for the Visual Arts* (2015). Retrieved September 15, 2017 from <http://www.collegeart.org/pdf/fair-use/best-practices-fair-use-visual-arts.pdf>

Entered at Stationer's Hall (London: M. Thomas, Franklin Press, 1871). Retrieved September 15, 2017 from https://books.google.com/books?id=3w8HAAAAQAAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false.

Gajanan, Mahita. "Controversial artist Richard Prince sued for copyright infringement," *The Guardian*, January 4, 2016, <https://www.theguardian.com/artanddesign/2016/jan/04/richard-prince-sued-copyright-infringement-rastafarian-instagram>.

New York City Bar Association Committee on Copyright and Literary Property, *Top Ten Copyright Myths*. New York, 2015. Retrieved September 30, 2017 from <http://www2.nycbar.org/pdf/report/uploads/20072995CopyrightMythsCOPLIT11.17.15.pdf>.

Rogers v. Koons, 960 F.2d 301 (2d Cir. 1992).

Stanford University Libraries. "Websites: Five Ways to Stay Out of Trouble," *Copyright & Fair Use*. Retrieved July 15, 2016, from <http://fairuse.stanford.edu/overview/website-permissions/websites/>.

Statute of Anne. 8 Anne, c. 19 (1710).

Tate Museum, "Appropriation." *Tate Online*. Retrieved August 15, 2017 from <http://www.tate.org.uk/art/art-terms/a/appropriation>

8 U.S.C. § 2319.

A Case Against the Institutionalization of the Full Art Process

Christopher Lynn

Brigham Young University

Abstract

*As art museums seek to reach new audiences and broaden the scope of their education departments, they not only exhibit work, but also produce didactic texts, catalogs, timelines, panel discussions, and docent-led tours to contextualize the art on view. They also often venture into artist video interviews, documentary videos of the work being made and/or installed, studio visits, and artist and curator lectures. By institutionalizing and centralizing the creation, installation, contextualization, and audience conversation, a single academic narrative is created to portray simply what is often a complex and multi-layered artistic and cultural process. In this paper, the author compares the display and treatment of artists' work in formal museums and artist-centered spaces, from the different presentation methods employed for the visceral work of William Pope.L, to Rirkrit Tiravanija's exhibition *Free* (1992) at the 303 Gallery in New York City and the Museum of Modern Art, and the*

attitudes toward art objects at the Chinati Foundation in Marfa, Texas, and the Pulitzer Arts Foundation in St. Louis.

When visiting an art museum or gallery today, in addition to experiencing art, visitors can expect to encounter artwork object labels, timelines, audio tours, mobile-phone tours, docent-led tours, explanatory video documentaries, or video interviews with the artist(s) and curator(s). They also may have access to interactive displays, artist lectures, curator lectures, specialist lectures, studio visits (for wealthy patrons), exhibition-specific websites and apps, emails, blog posts, artwork-themed workshops, surveys, questionnaires, or any other myriad of didactic materials or educational happenings geared to further explain the art to the public. However, this cluttered orbit of things and events can often obscure the work from the viewer rather than reveal it. By institutionalizing and centralizing the creation, installation, contextualization, and audience conversation, a single academic narrative is created to portray simply what is often a complex, conflicted, and multi-layered artistic and cultural process. This institutionalization begins with the best of intentions and a series of removals.

Removed from Source

The first, and most problematic step toward narrowing an individual's experience with the art is also one of the more essential steps: removing it from its original context and placing it in the public museum or gallery. The work is generally placed away from the artist and away from the studio. There are works that are created as site-specific or performed especially for particular exhibition spaces, but the bulk of work exhibited in traditional venues is not of this mode; it is portable and displaced. And though many artists expect their work to eventually live in the sterile and rarified environments of art institutions, the work is seldom created in such a situation, nor does the artist control the particulars of the gallery spaces—ceiling heights, lighting intensity, and proximity to and content of didactic text and neighboring work. The work is initially conceived of and executed in a variety of circumstances: cluttered studios crusted in layers of paint and dust with visual reference and notes papering the walls like a community billboard; home offices and studios either neatly organized or ensconced in bric-a-brac; warehouses; garages; workshops; and the like.

Donald Judd, an artist who was associated with the Minimalist movement and was a practical purist when it came to the ethics of artwork display, stated:

I don't think art is show business, and it's not commerce. When it's produced—generally when it's around someone's studio—it's in a very different situation than when it's in a museum or gallery. The attitude and the architecture of museums and galleries is very different from the original attitude of the work. And in a way, it's a falsification of the work. If you put paintings by Pollock, or Rothko, or Barnett Newman into the Museum of Modern Art—which is a relatively Moderne, fascist building—you put them in a fascist context. And that is bound to change people's attitude toward the art.¹

Land artist Robert Smithson distinguished between works done in the land (site) and works displaced to a gallery or museum (non-site). “Instead of putting something on the landscape, I decided it would be interesting to transfer the land indoors, to the Non-site, which is an abstract container.”² The container of the exhibition venue is platonically devoid of context and is meant to “mirror” the site in an abstracted way. Through Smithson's view, the nature of the work changes in translation. It is no longer a site, but a representation of the site. Work that is displaced from the site of creation or realization is intrinsically different and abstracted within the non-site of the museum.

Differentiation between the museum and the site is essential in acknowledging the purposes of the two locations. The site—studios, landscapes, and similar situations—is where ideas and objects are birthed and raised free range among kindred works, away from the public eye. Exhibition venues are for the upkeep of select specimens and their clean display for public view. These non-sites can be thought of in terms of wildlife preserves, zoos, or museums of taxidermy that replicate the environments of the site in differing ways.

Removed from Time

Exhibition catalogs that bear titles like *Painting Now!* feature color spreads of art that no longer represent “now” even before the catalogs make it to print. Time has flowed onward, artists have made new assumptions, and theories have shifted on their tectonic plates. Artwork begins aging the moment it is severed from the site or studio and begins its inevitable march from art to artifact.

¹ Chris Felver, *Donald Judd - Marfa Texas*, 24:54 (Pottstown, PA: MVD Entertainment Group, 2008), <https://www.kanopystreaming.com/product/donald-judd-marfa-texas>.

² Robert Smithson, “Earth,” in *Robert Smithson: The Collected Writings*, ed. Jack Flam (Berkeley and Los Angeles: University of California Press, 1997), 178.

The artificial environment of display institutions is often created with the best of intentions to highlight the artwork—to eliminate distractions and visual clutter and allow visitors to focus only on the work, while the architecture and notions of time fade into the background. Works from earlier eras are often presented in galleries painted muted colors to abstractly reference period-appropriate display modes, whereas artworks from the late-20th and 21st centuries are usually shown on or adjacent to clinically white walls. Artist and critic Brian O’Doherty wrote:

Unshadowed, white, clean, artificial—the space is devoted to the technology of esthetics. Works of art are mounted, hung, scattered for study. Their ungrubby surfaces are untouched by time and its vicissitudes. Art exists in a kind of eternity of display, and though there is lots of “period” (late modern), there is no time. This eternity gives the gallery a limbolike status.³

Much like the notion of a blindingly white heaven where immortal and ageless figures from disparate histories rub shoulders with one another, objects from different decades can occupy the same gallery space, and in doing so, occupy the same time—both contemporarily and atemporally. This is the intentional nature of the museum or gallery, to strip away and confuse the context of time—placing the artworks in suspended animation to extend their life. But, by doing so, the artwork is robbed of movement, change, and life. The works sit like frozen specimens, forever poised, but never acting. The writer and cultural critic Rebecca Solnit wrote: “During my years as an art critic, I used to joke that museums love artists the way that taxidermists love deer, and something of that desire to secure, to stabilize, to render certain and definite the open-ended, nebulous, and adventurous work of artists is present in many who work in that confinement sometimes called the art world.”⁴ The work shifts almost immediately from art—a living object in time—to merely artifact—an academic object without time.

These removals are expected by artists. They know that the work will leave the studio, that it will leave their presence and influence, and that it will be frozen within the atemporal bubble of a gallery or museum. They may even acknowledge that their work will reside in a

³ Brian O’Doherty, *Inside the White Cube: The Ideology of the Gallery Space* (San Francisco: The Lapis Press, 1986), 15.

⁴ Rebecca Solnit, “Woolf’s Darkness,” in *Men Explain Things to Me* (Chicago: Haymarket Books, 2014), 100.

“white cube,” but this anticipation does not inoculate the work from the removals. Those primary contexts may be hinted at within the work, but ultimately, they are gone.

Enriched White Art and Its Additives

Enriched white flour is produced through a process of bleaching the ground grain to make it more visually appealing, but through that process, most vitamins and nutrients are stripped away. The flour is then “enriched” to artificially reintroduce nutrients that were lost in the bleaching process.

Through the necessary removal of art from its site, the work is also divested of essential context about the work, its environments, its creator, and its time (complete with political, economic, and theoretical implications). This leaves a vacuum for the viewer of the work to interact profoundly and fill those spaces with personal interpretation and meaning. In “Death of the Author,” Roland Barthes addresses authorial issues of texts:

To give a text an Author is to impose a limit on that text, to furnish it with a final signified, to close the writing. Such a conception suits criticism very well, the latter then allotting itself the important task of discovering the Author (or its hypostasises: society, history, psyché, liberty) beneath the work: when the Author has been found, the text is “explained”—victory to the critic.⁵

By divorcing the work from the author, that authority of interpretation is passed to the reader to see how the text operates free from outside interference. The text can just be what it is. Unfortunately, the authorial vacuum is generally first filled by a curator who steps in to enrich the art with didactic material aimed at restoring lost context. When a curator steps in, she becomes a present, surrogate author imposing meaning and closing the writing. Viewers are told what to observe, how to interpret the art, which historical nuggets are pertinent to “understanding,” and what the artist said or intended. By closing off personal viewer interaction with a work, museums and galleries set up a single, simplified narrative to explain the art.

Through studied observation, focus groups and surveys, museums have begun to understand the descriptive limits of their audience’s at-

⁵ Roland Barthes, “Death of the Author,” in *Image Music Text*, trans. Stephen Heath (New York: Hill and Wang, 1977), 147.

tention spans. Visitors will read up to approximately 50 words on an object label and 150 words on room labels.⁶ These strictures mean that curators have to concentrate their educational efforts to a tight interpretation of the work that can be digested in a few seconds. These tidbits of didactic material lack any pretense of the complexity of how the work operates and the contexts from which it hails. They attempt to move from the obscured to the revealed. The Lebanese poet Gibran Khalil Gibran wrote, “Art is a step from what is obvious and well-known toward what is arcane and concealed.”⁷ Curators often see it as their job to reverse that process and lead to something concrete.

Viewers then frequently nullify their own views and instead defer to, and become dependent upon, what the former director of the Detroit Institute of Arts, Graham W. J. Beal, called “the priestly voice of absolute authority.”⁸ Similar studies of museum visitor behavior revealed that “visitors spend ten seconds in front of an object—seven to read the label, three to examine the thing itself.”⁹ They spend more than twice the amount of time dedicated to the voice of authority than they give to the work itself. There is no communion with the work without the intercessory curator.

Object labels are but one stone in the mountain of didactic mediums employed in 21st-century art institutions. Audio tours, video documentaries, websites, mobile apps, social media, interactive displays, lectures, and docents are also part of the pedagogical arsenal. Within those tools, the sources of content have extended to include artist interviews, historical material, documentation of the work being made and installed, and the musings of experts, the curator, or museum staff, among others.

Although most institutions attempt to deploy these tools tastefully and appropriately, there is little regard given to the fact that most of these are one-way communicators. The exceptions of blogs or other feedback mechanisms still do not allow for a real-time exchange of ideas. Docent or curator tours will allow for question-and-answer moments, but only after the visitors have been bombarded with educational rhetoric in an academic shock-and-awe campaign.

Aside from stylistic issues of contrast, font size, label size, and so forth, some attempts have been made to alter the object label format to

⁶ Gail Gregg, “‘Your Labels Make Me Feel Stupid,’” *Artnews*, July 1, 2010, accessed April 4 2017, <http://www.artnews.com/2010/07/01/your-labels-make-me-feel-stupid/>.

⁷ Faye Oweis, *Encyclopedia of Arab American Artists* (Westport, Conn.: Greenwood Press, 2008), xviii, 134.

⁸ Gregg, *Your Labels*.

⁹ *Ibid.*

be a series of questions rather than statements. However, even the posing of a question is building a frame around the work. Some institutions have invited audience members to have special advanced access to exhibition objects so they may write their own labels, which are then switched out every other week to diversify the voices and views.¹⁰ On the surface, this egalitarian approach sounds promising, however, the fact that the curator of education anointed specific responses meant that the museum maintained editorial control and therefore was still acting as the surrogate author.

Museums hear from patrons that they want to “connect with the artist.”¹¹ This is one of the reasons interactive displays are introduced that allow the artist’s recorded voice to talk about her work, impregnating the art with the author and her intentions again. When woven together with object labels and other didactic accoutrements, a tighter, more limiting narrative is built around the work that leaves little room for an audience’s autonomous rumination. In some cases, these efforts leave little room for the actual viewer.

Marc Fischer is a Chicago-based artist working under the name Public Collectors who helps run the publishing house Half Letter Press and who is part of the art collective Temporary Services. When visiting the Museum of Contemporary Art (MCA) in Chicago in 2015, he encountered an odd collision of art and education services intervention. In front of Kerry James Marshall’s painting *Untitled (Painter)* (2009) was a low barrier, in front of which sat a large wooden dais on which was written (Figure 1):

Responding to the absence of diversity in traditional Western art, Chicago-based artist Kerry James Marshall seeks to place the black artist and black subjects into art history. In anticipation of his major exhibition at the MCA this spring, we invite you to reflect on one of Marshall’s paintings, *Untitled (Painter)*, so we can learn more about how you would like to explore his work further.

Take a moment to reflect and share your thoughts on the cards here.

¹⁰ Salwa Mikdadi Nashashibi, “Visitor Voices in Art Museums: The Visitor-Written Label,” *The Journal of Museum Education* 28, no. 3 (2003): 21-25, <http://www.jstor.org/stable/40479306>.

¹¹ Gregg, *Your Labels*.

Marc took one of the accompanying note cards on which was printed the prompt: “If you could ask the artist anything, what would you want to know?” Marc penned the following response: “Why did you let the MCA place this podium in front of your painting, which makes it very hard to properly look at the work?”

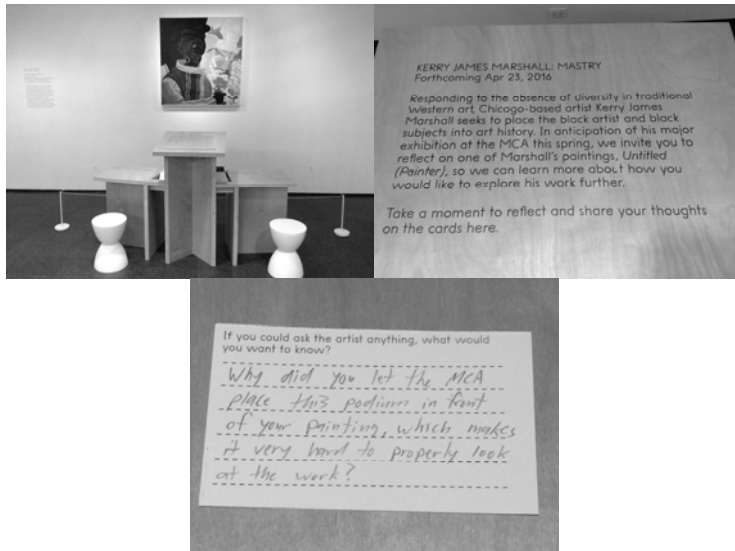


Figure 1. Images courtesy of Marc Fischer, 2015.

Place Additives

Other attempts to enrich artwork are exemplified by the Museum of Modern Art's (MoMA) 2011 acquisition and restaging of Rirkrit Tiravanija's *Untitled (Free)*, which was first created in 1992 at Gallery 303 in New York. For *Untitled (Free)*, Tiravanija moved Gallery 303's offices to the gallery and turned the office space into a functioning kitchen—cooking and serving free Thai green curry and rice. Visitors to the gallery, expecting to see objects mounted to the wall, floor, and/or pedestals, were instead greeted with the sweet and savory smell of curry. Often cited as part of the relational aesthetic movement, the work was not concerned with traditional, visual aesthetics, but opted for a less tangible experience of enjoying food in the company of friends and strangers. The art was the experience.

Tiravanija staged this work three more times in 1995, 2007, and finally 2011 at MoMA. In 2007, when the work was recreated in the David Zwirner gallery, he put many of the items from the original event

on display. The walls were clad in plywood, and skeletal, 2×4 walls were installed (sans drywall) to replicate a semblance of the original floorplan of Gallery 303. The same strategy was employed for the exhibition at MoMA. The museum then accompanied the exhibition with an audio tour and documentary video laying out the history of the piece, whose name was then changed to *Untitled (Free/Still)*.

With ephemeral, performative works that are executed at a specific place, there is a mysticism associated with their short life. The work is here and gone, and lives on in some documentation, but also in the minds of the participants. Once the work is recreated, especially with scale replicas of the original gallery space at a different location, the art becomes a non-site. It was removed from its place of birth and transferred an artificial environment that attempted to recreate the original. It was placed in a zoo.

The term “zoo” is being used somewhat critically here, because the work was being passed off as being roughly identical, but it wasn't. Once *Untitled (Free)* was created the first time, the cultural landscape changed. There was now knowledge of such a work of relational aesthetics. Recreating the experience lacked the surprise of the original. Each new iteration was informed by and became a simulacrum of the last. The work was no longer in the wild (site). It was somewhere else—somewhere synthetic and abstracted.

The audio tour and video just attempted to recreate, in the minds of the audience, the original event, so the audience could pretend that they were sitting in Gallery 303, when in fact they were in a cavernous room in MoMA while the food was being prepared downstairs, not in the gallery's office space.

Time Additives

The performance and installation artist William Pope.L's work is visceral, sometimes brutal, nuanced, and often tackles issues of race and power. His 2015 exhibition at The Geffen Contemporary at MOCA in Los Angeles, titled *Trinket*, was revisiting the central eponymous work that was first conceived and exhibited through Grand Arts in Kansas City. In the lead-up to the 2008 U.S. election, Pope.L created a massive flag—the kind you might see flapping over a mega car dealership located off the freeway—and set it proudly waving indoors through a series of strategically placed industrial fans. Over the course of its exhibition, the artificial winds frayed the flag at the seams and it fell apart.



William Pope.L, *Trinket*, 2008, installation view, Grand Arts, Kansas City, MO. Courtesy of the Artist, Mitchell-Innes & Nash, New York and Susanne Vielmetter Projects, Los Angeles. (artwork and image ©Pope.L)

In the lead-up to the 2016 elections, MOCA in L.A. sought to appropriate an artifact of an election past in a prescient contrast between the optimism of 2008 and the cynicism of 2016. Like Tiravanija's recreations of *Untitled (Free)*, *Trinket* brought with it the ghost of its past incarnation. This time, its history was used as an instructive tool to further infuse this object with meaning.

Other items and performances accompanied the titular flag, however, *LA Times* critic Christopher Knight remarked: "MOCA curator Bennett Simpson, who organized the show, added a handful of works. Partly they provide additional context to illuminate the flag piece, and partly they serve the pragmatic need to fill available gallery space."¹² Even these other works were being used as props and enrichment devices to reinfuse life into *Trinket*.

Alternatives

There are exemplary models out there who are earnestly questioning traditional contextual methods and seeking alternatives in order to better connect the public with the exciting ideas embodied within art. I will highlight a few such organizations.

¹² Christopher Knight, "William Pope.L Sets the U.S. Flag Waving at the MOCA/ Gefen," *LA Times*, March 24, 2015, accessed April 1, 2017, <http://www.latimes.com/entertainment/arts/la-et-cm-pope-l-moca-review-20150324-column.html>.

Art in the Wild

Between 2008 and 2013, I was the executive director of SPACES, a Cleveland-based, non-profit art venue dedicated to artists who explore and experiment. We sought to get people to interact more personally with our artists' projects. To that end, we regularly encouraged artists to take their art outside of our gallery if being in the gallery did not make sense for the work. One artist who took us up on our challenge was William Pope.L. He concocted a project called *Pull!* wherein we had to enlist hundreds of volunteers to help pull an 8-ton truck across the entire city of Cleveland over 48 hours as a means to foster dialog about the nature of labor. We worked closely with Pope.L to plan a route through the city that wound through neighborhoods of diverse socioeconomic and racial make-ups. We paid individuals experiencing homelessness to help pull the truck (they were the only paid pullers) shoulder to shoulder with business people, students, artists, and others. We had no leaflets expounding the nature of the project for passers-by. When curious people on the street asked what was happening, anyone participating could answer about their individual experience with the project. This generally started a dialog where citizens would talk in length about the jobs they held, the reasons they worked, and that everyone should have food, clothing, shelter, and hope for tomorrow.



William Pope.L, *Pull!*, June 7–10, 2013, social performance, Cleveland, OH. Courtesy of the artist, Paul Sobota, and SPACES. (artwork and image ©Pope.L)

Pull! was a work conceived to exist in the wild. The narrative about the undertaking was widely interpreted by viewers and rarely narrowed by those in authority. The project's success was in its flexibility and openness to being acted upon.

Using the metaphor of museums of taxidermy, zoos, and wildlife preserves, I advocate for the preserve model. Understanding that for most physical work to be experienced, it must be displaced, the metaphor of a preserve would be the most productive. When driving through a preserve, the animals may be fenced in to a degree but are still allowed more freedom and space than a cramped cage. They are rarely found in the same place every day, so stationary didactic panels are useless. Animals may interact liberally with one another, experiencing little delineation. If you want to understand the animals, you have to take some time to see how they move and act.

Audiences get a limited glimpse into natural life and habitats of animals in a zoo, but it is still more informative than looking at a stuffed bear forever frozen while swatting at a plastic salmon in a diorama.

Cut Out the Author and Authoritarians

Rather than having museum educators and curators standing between the work and the audience—teaching visitors that they need to have an interpreter whispering in their ear—some institutions have sought to empower audiences. The Museum of Contemporary Art (MCA) in Denver has a program called Art Fitness Training that takes audiences to different cultural institutions in Denver and gives them a loose framework they may apply to any artwork and gain insights. About their program, they say: “With an emphasis on close observation and easy to grasp principles, this three-part, participatory workshop is designed to give all audiences the ability to appreciate even the most difficult contemporary art.”¹³ Participants spend time describing what they see in the work, then they ask a “what if” question to prod the possibilities within the work: “What if it were ten feet taller?” “What if the artist were female instead of male?” Then the participants unpack what meaning can be found within the previous two steps. With great response from the public, the program has been loaned to other organizations around the United States, including the Utah Museum of Contemporary Art. Participants can wander through museums and galleries autonomously and not feel bullied by object labels and educa-

¹³ “Art Fitness Training,” *MCA Denver*, accessed January 12, 2018. <https://mcadenver.org/events/art-fitness-training-1>.

tional material. The program only runs seasonally with limited enrollment, so it is not a complete substitute for contextual material.

Build the Right Context

Donald Judd was living and working in New York City, but wanted to get out. He scoured the American Southwest and Mexico looking for a location where he could set up a studio and a place for his work to reside outside the commerce of the market. John Yau, a poet, teacher, and critic, outlined Judd's method to care for his work and the artists he admired:

In 1978, he's convinced the Dia Foundation to buy Ft. Russell—an army base that's no longer in use—and starts the Chinati Foundation. And really what he wants to do is establish a kind of utopian community—among other things, where artists can go and work, artists can be in residence, scholars can go and do research. He has a library set up—a print facility set up. But he also wants, and I think this is very important, he wants to give art dignity. I think that he felt that museums deprived art of their dignity. Donald Judd would think of a museum as a display window. That art's up for the right season, then it's gone and on to the next artist.

In the Chinati Foundation's catalog, Judd wrote:

It takes a great deal of time and thought to install work carefully. This should not always be thrown away. Most art is fragile and some should be placed and never moved again. Somewhere a portion of contemporary art has to exist as an example of what the art and its context were meant to be. Somewhere, just as the platinum-iridium meter guarantees the tape measure, a strict measure must exist for the art of this time and place.¹⁴

What the establishment of specialized foundations and bespoke art bunkers in the wilderness lacks in general practicality, it makes up for in gumption and flare.

¹⁴ "Chinati: Mission & History," Chinati, accessed April 2, 2017, <https://chinati.org/visit/missionhistory>.

Conversations About Art

When the Pulitzer Arts Foundation was built in St. Louis, it was dedicated as a sanctuary for art and the experience of art. Matthias Waschek, who was Director of the Pulitzer Foundation for the Arts from 2003 to 2011, addressed in a video why their galleries were devoid of placards: “On one level, there is no label because these labels interfere visually with the artwork.” He then went on to say:

There is a distance that is created. You have the impression that the knowledge physically co-exists with the aesthetics of the artwork. And, of course, knowledge is always there, and sometimes knowledge even focuses your view. But, what is knowledge if you cannot really trust your personal, physical experience of the artworks. That is what we are after. Additionally, our building is conceived in such a way, that there is a very intensive relation between three players, if you will: one is the artwork that is installed in the architecture, which means the second one is the architecture. And the third one is the visitor who is physically in the space—who feels his/her own body and who sees how the other bodies of the other visitors are cutting into the space and actually interacting with the artworks.¹⁵

Visitors can often find brochures on their exhibitions for more information, but the gallery walls and floors have nothing but artwork. Although the Pulitzer’s aesthetic is somewhat austere, it gives the artwork room to interact with the viewer without being interrupted by anything other than more art.

When I visited the Pulitzer a number of years ago, I was refreshed to find no visually distracting or authoritarian object labels. I strolled through the galleries with no disturbance other than what looked like a local art student trailing a bit behind me. I finished my exploration of the galleries and moved to the outdoor courtyard that housed Richard Serra’s spiraling, weathering steel, outdoor sculpture *Joe* (2000). As I reached the center of the spiral and spun around to return to the building, I found the young student standing in front of me, cheerfully asking, “Do you have any questions?” Since the querying individual lacked identification or a uniform, at first I assumed it was an overly

¹⁵ "From the Director: Why Are There No Labels on the Art?," 2010, YouTube video, 2:11, posted by Pulitzer Arts Foundation, January 13, 2010, <https://youtu.be/5A7AuPE1Lo8>.

enthusiastic patron eager to assist me, and that I must have looked particularly perplexed. I came to discover that these individuals were employed as plain-clothes didacts to engage visitors in conversation about the works when prompted.

Making It Work

Industry journals publish studies and postulations on the future of art education material including the object label and how to best use them as an educational tool, but rare is the publication that will call for institutions to reconsider their use as a default medium. In fact, most papers are geared to figuring out how to get visitors to look at and spend time with the placards.

Rather than defanging and declawing the artwork further through pedagogical intervention, institutions would do well to consider the worthier undertaking of preserving a piece's potential and ability to exist and communicate for itself, as well as the associated benefit to the museum patron of personal intellectual space and stretching that comes from an un-manicured encounter with an art work. Such an experience is often not easily digestible but has a higher likelihood of forging a meaningful and lasting connection between the audience, the artwork, and the presenting institution.

There is an economic simplicity behind the object labels. They do not require expensive technology; they sit at constant attention near the edge of the artwork, require no vacations or overtime pay; and once printed and adhered to the wall or pedestal, they will remain indefinitely. Placards are a more stable and practical effort than hired didacts, sporadic training of the public, and creating a new foundation; however, the practice generally does a disservice to the art. An institutional undertaking to move away from the well-trod and heavily scaffolded practice of deploying a rigidly on-message instructional and educational arsenal is a gamble given the presently pervasive and entrenched model. However, fidelity to the complexity of artworks and the vibrancy of artistic process preferences preservation of that vitality over reliable but narrow communication and explanation that becomes, even unintentionally, a redefinition. In the absence of the practical ability to thoroughly eschew re-authoring institutional models, museums, curators, and education departments can begin by prioritizing the wild artwork and an independent patron learning heuristically over a clean narrative. Institutions can redirect their energies to the consideration of how to invite an audience rather than to dictate to them, and how to maintain an artwork's unique nutrients and quirks.

Bibliography

Allen, Emma. "Curry Up!" *Artnews*, March 13, 2012. Accessed April 2, 2017 at <http://www.artnews.com/2012/03/13/curry-up/>.

"Art Fitness Training," *MCA Denver*. Accessed April 5, 2017 at <http://mcadenver.org/artfitnesstraining>.

"Audio: Rirkrit Tiravanija. Untitled (Free/Still), 1992/1995/2007/2011- (English)." *The Museum of Modern Art*. Accessed April 2, 2017 at <https://www.moma.org/explore/multimedia/audios/3/3243>.

Barthes, Roland. "Death of the Author." In *Image Music Text*. Transl. Stephen Heath, 142–148. New York: Hill and Wang, 1977.

"Chinati: Mission & History." *Chinati*. Accessed April 2, 2017 at <https://chinati.org/visit/missionhistory>.

Felver, Chris. *Donald Judd - Marfa Texas*, 24:54. Pottstown, PA: MVD Entertainment Group, 2008. Accessed April 2, 2017 at <https://www.kanopystreaming.com/product/donald-judd-marfa-texas>.

Fragomeni, Dana. "The Evolution of Exhibit Labels." *Faculty of Information Quarterly* [Online] 2, no. 1, 2010. <http://fiq.ischool.utoronto.ca/index.php/fiq/article/view/15408/12436>.

"From the Director: Why Are There No Labels on the Art?" Video, 2:11. Posted by Pulitzer Arts Foundation, January 13, 2010. Accessed April 2, 2017 at <https://youtu.be/5A7AuPE1Lo8>.

Gregg, Gail. "'Your Labels Make Me Feel Stupid'." *Artnews*, July 1, 2010. Accessed April 4, 2017 at <http://www.artnews.com/2010/07/01/your-labels-make-me-feel-stupid/>.

Knight, Christopher. "William Pope.L Sets the U.S. Flag Waving at the MOCA/Geffen." *LA Times*, March 24, 2015. Accessed April 1, 2017 at <http://www.latimes.com/entertainment/arts/la-et-cm-pope-l-moca-review-20150324-column.html>.

Landi, Ann. "Wall Talk: Do We Even Need Museum Wall Labels?" *Artnews*, December 21, 2015. Accessed April 3, 2017 at <http://www.artnews.com/2015/12/21/wall-talk-do-we-even-need-museum-wall-labels/>.

Mühlberger, Richard. "After Art History, What? A Personal View of the Shaping of Art Museum Education." *Journal of Aesthetic Education* 19, no. 2 (1985): 93-103. doi:10.2307/3332467.

Nashashibi, Salwa Mikdadi. "Visitor Voices in Art Museums: The Visitor-Written Label." *The Journal of Museum Education* 28, no. 3 (2003): 21-25.

O'Doherty, Brian. *Inside the White Cube: The Ideology of the Gallery Space*. San Francisco: The Lapis Press, 1986.

Oweis, Faye. *Encyclopedia of Arab American Artists*. Westport, Conn.: Greenwood Press, 2008.

Pekarik, Andrew J. "Another View: To Explain or Not to Explain." *Curator: The Museum Journal* 47, no. 1 (2004): 12-17.

"Rirkrit Tiravanija. *Untitled 1992/1995 (Free/Still)*. 1992/1995/2007/2011-." The Museum of Modern Art. Accessed April 2, 2017 at <https://www.moma.org/collection/works/147206>.

"Rirkrit Tiravanija | *Untitled (Free/Still)*." Video, 3:22. Posted by The Museum of Modern Art, February 3, 2012. Accessed April 2, 2017 at <https://youtu.be/0xRx2s3FpSg>.

Smithson, Robert. "Earth." In *Robert Smithson: The Collected Writings*, ed. Jack Flam. Berkeley: University of California P., 1997.

Solnit, Rebecca. "Woolf's Darkness." In *Men Explain Things to Me*, 85-106. Chicago: Haymarket Books, 2014.

Vogel, Carol, "Meals as Art at MoMA; David Altmejd at Peter Brant's Gallery." *New York Times*, October 27, 2011. Accessed April 2, 2017 at <http://www.nytimes.com/2011/10/28/arts/design/meals-as-art-at-moma-david-altmejd-at-peter-brants-gallery.html>.

Wallis, David. "Labels, Digital Included, Assume New Importance at Museums." *New York Times*, March 17, 2015. Accessed April 3, 2017. at <https://www.nytimes.com/2015/03/19/arts/artsspecial/labels-digital-included-assume-new-importance-at-museums.html>.

Williams, Patterson B. "Object Contemplation: Theory into Practice." *Roundtable Reports* 9, no. 1 (1984): 10-12.

The Arts: A Means to Address the Problems of an Economic Model of Education

Kathleen Bunker Sheffield

Brigham Young University and Southern New Hampshire University

Abstract

The educational system of the United States is currently facing challenges that include rising dropout rates, a narrowing curriculum, excessive standardized testing, a widening achievement gap, and an increasingly diverse student population. In our ever-changing world, the arts can be a means by which the purposes of education can be balanced and the problems of economic and intellectually driven models of education can be addressed. In an economic model, teaching and learning are driven by efficiency and rationalism. In an intellectual model, education is seen as an academic ability determined by memorization and the ability to learn by rote. These models assume that intelligence can and should be measured to determine progress. Interpersonal and creative processes are left by the wayside. Assessment-driven practices only consider improvement that is easily measured. The arts are marginalized under these practices. Dismissing

the arts as a vital part of education limits the development of the full spectrum of human intelligence. The arts are instrumental in fortifying intrinsic benefits of an individual's identity, values, feelings, perceptions, opinions, and motivations. New technologies of the future require new capacities and abilities. The arts have the potential to encompass and promote the intellectual, cognitive, humanistic, creative, socio-emotional, socio-cultural, and socio-economic aspects of education. The arts can be the means by which we begin to integrate greater learning, limit the impact of socio-economic disparity, and encourage creativity, individuality, humanness, and cultural diversity.

The arts should play a quintessential role in education. Currently, the role they play is often varied and underestimated. At present in America, our schools are facing monumental challenges. We are fighting rising dropout rates, a narrowing curriculum with a strict focus on standardized testing, a widening achievement gap between our highest and lowest performing students, and a predominately white teaching force engaged in instructing an increasingly diverse student population. Additionally, many of America's students are struggling to find their individual and cultural identity.

According to Sahlberg (2009), there are two models of education: an economic model and an intellectual model. In an economic model, education is considered the production of skills and knowledge where teaching and learning are driven by efficiency and rationalism. Competition and information are paramount in this kind of a model. In an intellectual model, intelligence is considered predominantly an academic ability driven by memory and rote skills. An intellectual model does not value or measure broader intellectual abilities that include interpersonal abilities and the creative process, and it assumes that intelligence can and should be measured to determine progress (Salberg, n.d.).

In his book *Out of Our Minds: Learning to be Creative* (2011), Sir Ken Robinson lists three main purposes of education. They are: "Individual: to develop individual talents and sensibilities; Cultural: to deepen understanding in the world; and Economic: to provide the skills required to earn a living and be economically productive" (2011, p. 39-40). These three purposes and how they relate to each other are vital in the transformation of existing educational paradigms to meet the needs of the 21st century and beyond (Robinson, 2011).

Economic and intellectual purposes are only part of the picture and should not be the sole motivation and focus of our current educational system. In our ever-changing world, the arts can be a means by

which the purposes of education are balanced and the problems of economic and intellectually driven models of education are addressed.

No Child Left Behind

Ideas about education and its purposes and outcomes are numerous and varied. Educational reformer John Dewey's idea of education has the rights and responsibilities of the learner at the center. Dewey also believed that knowledge that comes from experience is superior to knowledge that comes from authority. In our schools today, many of the rights and responsibilities of the learner seem to be secondary. Furthermore, much of the knowledge that is taught comes from authority and not from experience. Although Dewey's beliefs about education espoused over 100 years ago might seem antiquated to some, it is this author's position that it is appropriate to apply Dewey's thinking to the struggles of our day. In our schools today, many of the rights and responsibilities of the learner seem to be secondary. Twenty-first century educators need to consider what the needs of the learner are and how best to facilitate them. We are still recovering from the effects of the federally mandated No Child Left Behind (NCLB) Act of 2001, which targeted struggling populations and schools in an attempt to close the achievement gap by placing an overemphasis on student achievement and testing specifically in the core subject areas (Boykin & Noguera, 2011). NCLB helped to direct the focus of educational purposes towards those of economic and intellectual models.

"The National Education Association believes the arts play an important role in providing students with a well-rounded education" (Walker, 2012, para. 10). But a well-rounded education has come to mean a scientifically based education, which can be measured and assessed primarily by economic and intellectual values.

In almost every section of the law, NCLB [stressed] that decisions about the allocation of federal resources for education should be grounded in 'scientifically-based research.' The intent, as interpreted by the Department of Education, [was] to transform education into an evidence-based field. (National Assembly of State Arts Agencies, 2006, p. 4).

NCLB helped to create practices that are assessment driven, where the primary focus has been only on improvement that can be measured. The needs of the learner are not at the center of this kind of a model, but instead are secondary to those of measurement-driven, teach-to-the-assessment processes.

[An] homogenized educational system and its proponents' desire to audit, classify and calibrate and, thereby, reduce people—particularly children—to metrics... The forms that education takes are fundamentally affected as a consequence of this: all components or features that can be readily measured are valued highly, those that cannot are marginalized or eliminated all together. (Adams & Owens, 2016, pp. 13,15).

Interestingly enough, the arts were also a part of the NCLB mandate, which included arts as a core subject. However, schools in many states have reported that a greater amount of instructional time each day has been devoted to reading, writing, math, and science, while instructional time for the arts has declined (Zastrow & Janc, 2004). “The arts remain on the margins of education, often the last to be added and the first to be dropped in times of strained budgets and shifting priorities” (National Assembly of State Arts Agencies, 2006, p. 17). NCLB has strengthened the belief that students should be judged and valued by how well they do on standardized tests.

Art, music, and even physical education are not tested subjects, so in many schools they are treated as extras that can be cut... Sadly, rather than moving us forward, NCLB has reinforced the tendency to make premature and often inaccurate judgments about the abilities of children and has left the so-called achievement gap, which it was designed to ameliorate, largely untouched. (Blankstein & Noguera, 2016, para. 36)

Many current trends in education are still following the mandate of NCLB in working to close the achievement gap between disadvantaged and minority students and their peers. When competitive and academically driven abilities, which focus on memory and rote skills, are increasingly valued, individual and cultural purposes also become undervalued. The arts can provide necessary experiential learning activities wherein individuals can make application to real life situations.

Developing a Student's Identity

Sir Ken Robinson considers a system of education that places an overemphasis on the technical, to be a system, which naturally undervalues or overlooks what he calls the ‘human factor.’ The ‘human factor’ includes the values, feelings, perceptions, opinions, options, and motivations of individuals and the means of communication between them (Robinson, 2011). An educational model, which supports and

encourages the development of student identity, echoes Dewey's belief that a prime value of the arts lies in its foundational support of humanity.

The expression of individual identity is all too often discouraged, misinterpreted, and unrewarded. Art is a means to explore identity, to celebrate and promote self-expression and its diversity. Through this expression dialogue is created that speaks to community, acceptance, and the safeguards that are necessary for expressing individual identity in a society. (Dowling, 2011, p. 2)

Many factors affect the shaping of an individual's identity including gender, sexual preference, age, social class, race, and cultural heritage, early relationships, and socialization. "An identity as a student is critical to learning and achievement because it functions as an organizing and interpretive framework with a wide-ranging set of influences on a student's behavior in school" (Minow, Shweder, & Markus, 2008, p. 64). Often the confining structure of our test-driven educational system perpetuates rigid parameters about who our students are and how they are allowed to express their ideas and develop their identities. A study commissioned by the Wallace Foundation recognizes how art experiences have both intrinsic and instrumental benefits. Intrinsic benefits are those gains that are inherent from the art experience itself. An education rich in the arts encourages students to

...interpret, express, perform, and create, their experiences lived and scaffolded on the artwork of others... In school, these aspects are reconciled in social processes of learning, by interaction with peers, making, examining, and reflecting on art while also creating new ideas or art products. Students learn they possess the ability to change things. As active participants, they are capable of taking action to express pleasure or displeasure. (Goldblatt, 2006, p. 25)

Intrinsic benefits like these also help to develop a student's identity. They are evident as benefits when the arts are integrated as a primary function of the education model. Additional intrinsic benefits come from the dealings between student art participants and those with whom they interact.

These intrinsic effects enrich individual lives, but they also have a public spillover component in that they cultivate the

kinds of citizens desired in a pluralistic society... [Additional intrinsic benefits include] social bonds created through reflection and discourse, and the expression of common values and community identity through artworks commemorating events significant to a nation's (or people's) experience. (McCarthy et al., 2005, para. 6)

One of the views of our day is that the arts have value because they support social and economic goals as well as better academic performance. Benefits like these would be considered instrumental benefits because the arts are the instrument used for achieving them. "The evidence is clear: study of the arts contributes to student achievement and success. Its multiple benefits are academic, basic and comprehensive" (National Assembly of State Arts Agencies, 2006, p. 17). Students who gain experience in interpreting, expressing, performing, and creating gain a better understanding of themselves, and their ability to effect change on the world around them. These benefits are evident when the arts are integrated as a primary function of the education model.

Linda Yaron (2016), a high-school English teacher in Los Angeles, created a partnership with her students and the Getty Museum to create a photography exhibition in the community. Yaron's students were given studio time and instruction with international artist Tomoko Sawada. He guided them through the elements of self-portraiture. The students created individual works that were displayed in a two-week exhibition at a community café. Participating students had these things to say about their experience: "It allowed me to find my identity and it helped me find what really represents me." and "The experience helped me look deeper inside myself and be vulnerable enough to let myself and others in to help me figure it out. It impacted me to be open with myself." (Yaron, 2016, para. 6).

Not only should teachers work to create experiences for their students like Yaron did, teachers and staff need to be intentional in valuing and seeking to understand their students. They should also be active in countering any behavior or practice that undermines, devalues, or limits students and their emerging identities. Teachers who do this will "increase the likelihood that students will claim a student identity and that others will confer this identity on them" (Minow et al., 2008, p. 83).

It should come as no surprise that creative subjects and creative acts are commonly marginalized in state schools throughout the industrialized world. Teachers associated with creativity accrue fewer funds and frequently have less power.

The hierarchal managers within schools put creativity low down on their priorities, and they are normally vigilant to ensure that the ethos of the institution remains conformist and obedient. (Adams & Owens, 2016, p. 17)

The Center for Arts Education published a report in 2009 that studied dropout rates in New York's public schools. This report found that schools with the lowest access to the arts in educational programs also had the highest dropout rates; those with the highest access to arts in education programs maintained the highest graduation rates. "Participation in [art] activities has a quantifiable impact on levels of delinquency, truancy and academic performance" (Center for Online Education, n.d., p. 5).

The scheme of a curriculum must take account of the adaptation of studies to the needs of the existing community life; it must select with the intention of improving the life we live in common so that the future shall be better than the past... There is truth in the saying that education must first be human and only after that professional. (Dewey, 1916, p. 147)

We are losing the tangible humanness of education and its purposes, and replacing it with numerical data, which supports mandated improvement in more ordered areas of study. A driving force in educational reform has now become focused on the kind of skills and tools students will need for the future rather than simply replicating what has seemed to work in the past.

Life in the twenty-first century has become very complex, and the educational requirements for success have grown accordingly. A glut of information reaches us through television, the Internet, and other electronic media. Multimedia technologies bombard us with images and sounds. Job skills are changing at an accelerating rate. Political and economic events across the globe have a profound effect on our prosperity and security at home.... Because the liberal arts span the domains of human experience, they afford the best foundation for the diverse challenges that confront us in this rapidly evolving world. At the same time, a liberal arts education returns us to first principles, fostering an understanding of what it means to be human, an understanding that transcends limiting conceptions of occupation, social class, race, or nationality. An education

once reserved for the most privileged students has therefore become a necessity for all students. (Zastrow & Janc, 2004, p. 9)

Cultural Competencies

It is a misconception to view education as only obedient behavior that can be qualified and quantified as data (Adams & Owens, 2016). Educational programs that favor this priority are functioning under economic and intellectual purposes. Yet, the benefits of an educational experience rich in the arts can help communities to come together, transcend socio-economic boundaries, and support cultural differences (Hanley et al. 2013).

The arts not only address human elements and the developing identity of the individual, they are also the indispensable means by which equitable cultural and socio-economic experiences can take place as a part of the curriculum. Students need to be provided opportunities that can deepen their understanding in the world. These opportunities should include a perspective and experiences that can lead to understanding and tolerance with the diverse cultures and populations with which they live and associate. Advancing technology and science has helped us to quantify so many aspects of our world. But of what use is this advancement, unless it assists in the development of a society, which is founded on common purpose and interest?

A curriculum, which acknowledges the social responsibilities of education, must present situations where problems are relevant to the problems of living together, and where observation and information are calculated to develop social insight and interest. (Dewey, 1916, p. 148)

The erosion of instruction in the arts as an equal part in the curriculum narrows the definition of success by including only part of the spectrum of human intelligence. Minorities and lower socio-economic populations are also more likely to experience a narrowing of the curriculum and an absence of the arts (Hanley, Noblit, Sheppard, & Barone, 2013). In addition, broad generalizations about race and culture are so deeply rooted in our beliefs where educational struggles are concerned, that even when research and evidence suggests otherwise, stake holders continue to support the false bias of lower ability and potential in minority races. (Boykin & Noguera, 2011).

The most relevant studies provide no evidence for the genetic superiority of either race, but [instead provide] strong evidence for a substantial environmental contribution... Almost equally important, rigorous interventions do affect IQ and cognitive skills at every stage of the life course. (Jenks & Phillips, 1998, p. 101)

Researchers now recognize that student outcomes can be vastly improved by the incorporation of practices that seek to develop the diverse cultural identities of racial and ethnic minorities and their unique contributions to the current curriculum. Cultural competence is seen as both a moral and ethical responsibility in the creation of a welcoming environment in which all students are able to succeed (Howard, 2006).

Culture too is often associated with the arts. However, we relate the arts to a broader definition of social culture, which includes the impact of science and technology on ways of life and the increasing interaction between cultures. Young people need to be helped to engage positively with cultural change and diversity. The dangers of cultural intolerance make this task a particular priority. We argue that creative and cultural education are dynamically related and that there are practical implications for the curriculum and for the classroom. (National Advisory Committee on Creative and Cultural Education, 1999, p. 10)

Educators can have a profound impact by challenging and motivating diverse student populations by helping to create a learning environment that supports cultural diversity along with valuing creative problem solving. Teachers can become catalysts in initiating and sustaining dramatic improvement in our educational system and student outcomes (Pippens, 2013).

We have a responsibility to our students to assure that we and our colleagues remain open to even deeper levels of awareness... If our examination and understanding of the root causes of social inequality are too shallow, then our approach to corrective action will necessarily be superficial and ineffective. (Howard, 2006, p. 30)

While it might seem like a lofty goal to extend education beyond our present accepted boundaries, incorporating the arts as a founda-

tional aspect of American education can assist learners from every socio-economic class, all the while incorporating individual and communal cultural identity, diversity, and competence. We need to be “committed to equitable opportunities and outcomes to all our students” (Howard, 2006, p. 38).

In 2016, a special piece of choreography was created for a large community celebration to be held in Provo, Utah. The choreographer of this particular dance was working with a diverse cultural population. A portion of the piece required the manipulation of several 12-inch inflatable balls. During the first rehearsal with the balls, the choreographer worked with six or seven dancers and incorporated their ideas in creating the movement for this portion of the dance. By the end of the day’s rehearsal, the movement and interaction between dancers for the portion of the piece using the balls appeared fairly polished.

One week later as the dancers arrived to rehearse again, the choreographer was surprised to find that this section of the dance was less cohesive than at the previous rehearsal. Once again the choreographer went to work to refine and clarify the section of the dance with the balls. Yet again, one week later, at the next rehearsal, the choreographer was surprised to observe confusion and chaos as the dancers attempted to perform this section of the dance with the balls.

She found herself perplexed by the difficulty that the dancers seemed to be having on their retention of the movement material for this part of the dance. Until, that is, she realized that there were six different dancers using and articulating the balls than she had had the previous week. Soon after she discovered that the dancers working with the balls were also different from those in the original rehearsal.

The choreographer had been operating with the belief that the dancers that had originally been selected would repeat the part they had been given. This could be considered a hierarchal social structure. But the dancers were operating with the belief that everyone should be given an opportunity to dance with a ball. This could be considered a horizontal social structure. Culturally, the choreographer had been organizing and preparing the choreography from her cultural perspective, “It’s your part and you get to do it.” But her dancers had been performing under their own cultural perspective, which involved “giving everyone a turn.” Needless to say, the choreographer regrouped and recreated this section of the dance to accommodate the alternate social structure that considered an alternate cultural perspective and allowed for multiple casts of ball dancers.

While differing social structures can reflect cultural diversity, and teachers and artists may use this evidence as means of navigating and validating culturally diverse populations, other parameters can thwart

the abilities of teachers and programs from meeting the needs of students. Monetary resources often serve as boundaries that limit the availability of arts programs in educational experiences for those socio-economically challenged.

The most troubling finding... is the ‘equity gap’ between the availability of arts instruction for students in more affluent schools compared to those in high-poverty schools. Economically-disadvantaged students simply do not have the same access to the diverse learning experiences including arts of affluent students (Walker, 2012, para. 6).

In some cases, white hegemony limits the amount of arts that are available for minorities and underprivileged populations. Changing our thinking about this can move us in the right direction. “By redirecting the resources and the power that has been available to us because of dominance, we can be instrumental in shifting the flow of education towards greater equity and inclusion” (Howard, 2006, p. 67).

When top administrators support the arts, this does not necessarily mean that it trickles down to instruction in the arts for America’s students. When teachers and schools are required to focus on the improvement in test scores of non-art subjects, this is where the content of teaching will be focused. Maintaining common values wherein all members of a society have an equal opportunity to receive and share ideas in a variety of experiences is the basis of true education. Without these common values and equal opportunities, “the influences which educate some into masters, educate others into slaves” (Dewey, 1916, p. 65).

All kinds of benefits for American students are provided by immersive experiences in the arts; these are intrinsic and instrumental benefits that encompass and promote the intellectual, cognitive, humanistic, creative, socio-emotional, socio-cultural, and socio-economic aspects of education. All American students—no matter their race or socio-economic status—should have the opportunity to participate in art-based experiences that value and support their cultural perspective. Far too many schools lack the funding or the bureaucratic support to make this a priority. The fear of sacrificing academic achievement often withholds art-enriched programs from our most impoverished students.

Cultural capital is created when the collective sum of individuals participating in the educational experience value, support, and invite an environment wherein cultural diversity and socio-economic equality is

encouraged and acknowledged. Teachers are instrumental in creating and perpetuating cultural capital.

‘Art does not solve problems, but makes us aware of their existence,’ sculptor Magdalena Abakanowicz has said. Arts education, on the other hand, does solve problems. Years of research show that it’s closely linked to almost everything that we as a nation say we want for our children and demand from our schools: academic achievement, social and emotional development, civic engagement, and equitable opportunity. (Smith, 2009, para. 1)

Creativity in the Classroom

On the top of the list for skills needed in our changing world is creativity. Young and old alike have creative capacities and need to continue to develop them. “Developing these capacities involves a balance between teaching skills and understanding, and promoting the freedom to innovate, and take risks” (National Advisory Committee on Creative and Cultural Education, 1999, p. 10). It is believed by some that creativity is the most important human resource of all (Frank, 2011). Teachers can employ creative strategies in the classroom by asking students to synthesize concepts in original and new ways. They can include exercises that allow students to brainstorm multiple ideas and solutions to problems, and they can encourage students to communicate thoughts and concepts in new and innovative ways.

Education throughout the world faces unprecedented challenges: economic, technological, social, and personal. Policy-makers everywhere emphasize the urgent need to develop human resources, and in particular to promote creativity, adaptability, and better powers of communication (National Advisory Committee on Creative and Cultural Education, 1999, p. 9).

New and emerging jobs and types of work increasingly rely on high levels of specialized knowledge as well as on creativity and innovation. New technologies for a new age require different capacities and abilities from those that have in the past been sufficient for an industrial economy.

These technological changes, combined with population and climate changes, are affecting everyone on earth and the out-

comes are essentially unpredictable. What is certain is that in the next 50 to 100 years, our children will need to confront challenges that are unique in human history. (Robinson, 2011, p. 6)

Technological advancements have an impact on how students learn. Learning is no longer solely based on the written word. Images and screens are overtaking the power of paper as the most widely used means of distributing information (Kress, 2005).

U.S. education is dominated by standardized curricula, instructional systems, and assessment procedures. Due to the complex and rapidly evolving technologies, standardized assessments have overlooked the richness and unpredictable nature of inquiry that includes experiential and uniform reactions alike. Learning evidence need not be only standardized; it can be holistic, multi-methodological, and qualitative, full of experiential evidence. That experience encompasses the visual, audio, verbal, and now kinesthetic, as virtual worlds enable art teachers to view their students' three-dimensional accounts of learning. (Stokrocki, n.d., para. 11)

It is hard to imagine teaching that models and values creativity but fails to demonstrate its own creative methods and practices. Teachers need to not only encourage creative problem solving as a part of their daily plans for student experiences, but they also need to model their own behavior as an example of this belief. Teachers can promote and nurture creativity in the classroom. They should recognize the potential of their students' creative capacities and provide an environment wherein each student can consider and realize their own creative capabilities.

Creativity can be 'taught.' Teachers can be creative in their own teaching; they can also promote the creative abilities of their pupils. The roles of teachers are to recognize young people's creative capacities; and to provide the particular conditions in which they can be realized. Developing creativity involves, amongst other things, deepening young people's cultural knowledge and understanding. This is essential both in itself and to promote forms of education which are inclusive and sensitive to cultural diversity and change. (National Advisory Committee on Creative and Cultural Education, 1999, p. 11)

The ways in which teachers exemplify their own outlook on the world and demonstrate the importance of valuing their students' ideas can be a valuable asset that contributes to the transformation of existing educational paradigms. Educator Glenn Singleton, author of *Courageous Conversations About Race: A Field Guide for Achieving Equity in Schools* (2005) has this to say about a teacher's influence:

The most powerful thing that a teacher brings to school every-day is not curriculum, it's themselves. To know how I'm looking at students. To know how I look at the world is the most critical piece of my teaching strategy. So then when students respond to me, I understand how they are connecting to me. (Pippens, 2013, para. 1)

A clear example of this kind of teaching strategy was evident in a creative dance class with five-year-old children. The children were seated on the floor working on the difference between a rounded curved back and a stretching straight back. At one point in the sequence, the children were pretending to catch an imaginary soccer ball with their stomachs, which would cause their backs to respond by rounding back while sitting. The children's feet were stretched out straight with their toes pointed during the practice. As the children were repeating the exercise, one of the children flexed her feet instead of keeping them stretched when she used her torso to catch the imaginary ball. The teacher noticed and encouraged the other students to try "Kira's" idea as an opportunity for discovery when they repeated the exercise.

Daily classroom experiences like this that are student focused can provide a laboratory for children to value the exploratory process, their own creative ideas, and the innovative ideas of others.

If we want to develop creativity across multiple fields (and we do) students need to be literate in written languages, mathematics, visual languages, computers, health, and more. To focus on creativity is not to put aside these skills for unbounded playtime, but to situate these skills in real creative applications. And it definitely means focusing on the kind of 'higher order thinking' that we say we want from schools, but that are rarely prioritized in public education. (Kuttner, 2012, p. 4)

Brain-based Research in the Arts

The brain is no longer considered a static organ that undergoes few changes after early childhood. Instead the field of neuroscience

continues to provide a clearer understanding of the neural pathways and synapses and their continued adaptation in response to experiences, behavior, and the environment (Blankstein & Noguera, 2016; Jensen, 2009).

A growing body of neuroscientific research suggests that experience can actually change both the brain's physical structure and its functional organization well into adulthood. (Blankstein & Noguera, 2016, para. 42)

Once again the arts can be a means of providing experiential opportunities for all students. By creating and supporting the function of new and existing neural pathways, the arts can be a solution that reaches and teaches every type of learner.

In another study conducted over a four-year period, students that participated in regular music classes were found to have significant changes in their brains that were transferable to other motor skills in related areas. "Other studies reported similar scientific findings on the arts' impact on the brain, showing that sustained arts education can be an essential part of social and intellectual development" (Center for Online Education, n.d., p. 6).

It appears that educational experiences with a strong foundation in the arts extend, support, and connect intellectual, social, and cultural aspects of learning.

When the arts are integrated into the regular classroom curriculum and used to provide experiential knowledge about abstract ideas, students are able to grasp, understand, and apply new and complex information. Arts integration is more than including arts instruction as a part of class.

It is a teaching strategy that seamlessly merges arts standards with core curricula to build connections and provide engaging context. For example, in a science classroom you might see students choreographing a dance using locomotor and non-locomotor movements to demonstrate their understanding of rotation versus revolution of the planets. (Nobori, 2012, para. 3)

Arts integration uses teaching methods that are confirmed by brain-based research to improve comprehension and long-term retention. These methods help to better imbed the newly acquired information inside the learners' minds as they become active participants in the acquisition of new ideas and curriculum (Marien, 2011). Giving learn-

ers firsthand experience in understanding new and often confusing concepts is another way that an education supported and founded in the arts can give students the skills needed for tomorrow.

Conclusion

The effects of the lack of educational experiences centered in the arts is only compounded by a day and age “characterized by the availability of abundant information, advanced technology, a rapidly changing society, greater convenience in daily lives, and keener international competition” (Darling-Hammond, 2010, p. 1). We find ourselves on a slippery slope driven by achievement scores that no longer meet the needs of our diverse population.

Students should be exposed to a broad and rich curriculum that includes not only math and reading, but courses and clubs that focus on dance, music, art, theater and other creative disciplines. The arts are important. They enrich our lives. They have always offered ways to learn and express ideas. (Walker, 2012, para. 11)

By placing a greater emphasis on mathematics and reading in an attempt to close the achievement gap, especially in at-risk populations, we are simply substituting one form of inequality for another.

‘When you think about the purposes of education, there are three,’ says Tom Horne, Arizona’s state superintendent of public instruction. ‘We’re preparing kids for jobs. We’re preparing them to be citizens. And we’re teaching them to be human beings who can enjoy the deeper forms of beauty. The third is as important as the other two.’ (Louie, 2016, para. 2)

The arts should play a quintessential role in education. NCLB has created practices that have been primarily assessment driven, practices that have focused solely on improvement that can be measured. We are losing the tangible humanness of American education. Its purposes are being replaced with numerical data that supports mandated improvement in only designated ordered areas of study. With a greater emphasis being placed on mathematics and reading we are simply substituting one form of inequality for another.

The confining structure of our test-driven educational system perpetuates rigid parameters about who our students are and their developing identities. “The evidence is clear: study of the arts contributes to

student achievement and success. Its multiple benefits are academic, basic, and comprehensive” (National Assembly of State Arts Agencies, 2006, p. 17).

Teachers need to encourage creative problem solving as a part of students’ daily classroom experiences. They also need to model their own behavior as an example of this belief. When students participate in regular artistic-centered experiences, significant changes in their brains occur that are related to other areas of achievement. New research shows that student outcomes can be vastly improved by the incorporation of racial and ethnic minorities and their contributions, identities, and culture in the current curriculum. The arts are one vehicle by which this can be accomplished. By helping to create a learning environment that supports cultural diversity, values creative problem-solving, and incorporates art-based experiences, teachers can become catalysts in initiating and sustaining dramatic improvement in the educational system and student outcomes.

Maintaining common values wherein all members of a society have an equal opportunity in receiving and sharing ideas in a variety of experiences is the basis of a true education. A plethora of benefits await American students when they are provided immersive experiences in the arts. The benefits are intrinsic and instrumental and encompass and promote the intellectual, cognitive, humanistic, creative, socio-emotional, socio-cultural, and socio-economic aspects of education.

Technological advancements will continue to have an impact on how students learn. Images and screens will continue to replace the power of paper and the written word. “Whatever the future brings, digital worlds will be vibrant sites for investigating these new participatory multi-literacies in art education” (Stokrocki, n.d., para. 14). In our ever-changing world, the arts can be the means by which we begin to integrate greater learning, limit the impact of socio-economic disparity, and encourage creativity, individuality, humanness, and cultural diversity. The arts are one means by which the purposes of education can be balanced and the problems of economic and intellectually driven models of education can be addressed.

References

- Adams, J., & Owens, A. (2016). *Creativity and Democracy in Education*. New York, NY: Routledge.
- Blankstein, A. M., & Noguera, P. (2016). Introduction: Achieving Excellence Through Equity for Every Student. Retrieved September 5,

2017 from <http://www.ascd.org/publications/books/116070/chapters/Introduction-Achieving-Excellence-Through-Equity-for-Every-Student.aspx>

Boykin, A. W., & Noguera, P. (2011). *Creating the Opportunity to Learn*. Alexandria, VA: ASCD.

Center for Online Education. 10 Salient studies on the arts in education. (n.d.). Retrieved February 2, 2016 from <http://www.onlinecolleges.net/10-salient-studies-on-the-arts-in-education/>

Darling-Hammond, L. (2010). *The Flat World and Education*. New York: Teachers College, Columbia University.

Dewey, J. (1915). *The School and Society*. Chicago: Univ of Chicago Press. [Questia digital version]. Retrieved January 18, 2016 from <https://www.questia.com/read/101427392/the-school-and-society>

Dewey, J. (1916). *Democracy and Education: An Introduction to the Philosophy of Education*. New York: MacMillan

Dowling, S. J. (2011). *Constructing Identity, Identity Construction* (Masters thesis). Georgia State University. Retrieved February 7, 2016 from http://scholarworks.gsu.edu/art_design_theses/88

Frank, E. (2011, September 18). Now, more than ever before, the world needs creativity. *Business Times*. Retrieved February 7, 2016 from <http://www.sundaytimes.lk/110918/BusinessTimes/bt07.html>

Goldblatt, P. (2006). How John Dewey's theories underpin art and art education. *Education and Culture*, 22, 17-34.

Hanley, M. S., Noblit, G. W., Sheppard, G. L., & Barone, T. (Eds.). (2013). *Culturally Relevant Arts Education for Social Justice*. New York, NY: Routledge.

Howard, G. R. (2006). *We Can't Teach What We Don't Know*. New York, NY: Teachers College Press.

Jenks, C., & Phillips, M. (Eds.). (1998). *The Black-White Test Score Gap*. Washington, DC: Brookings Institution Press.

Jensen, E. (2009). *Teaching with Poverty in Mind*. Alexandria, VA: ASCD.

Kress, G. (2005). *Literacy in the New Media Age*. New York, NY: Routledge.

Kittner, P. (2012). School Reform: Chicago teachers tell a new story. Retrieved August 18, 2017 from <http://culturalorganizing.org/chicago-teachers-tell-a-new-story/>

Louie, D. (2016, February 26). Save the arts, save education [Blog post]. Retrieved August 18, 2017 from <https://deniselouieblog.wordpress.com/2009/02/26/>

Marien, T. (2011). Why integrating art into the classroom may improve retention. Retrieved August 18, 2017 from <https://artplantaetoday.com/2011/09/30/why-the-arts-improve-content-retention/>

McCarthy, K.F., Ondaatje E.H., Zakaras, L., Brooks, A. (2005). Reframing the debate about the value of the arts. Retrieved from August 18, 2017 from http://www.rand.org/pubs/research_briefs/RB9106.html

Minow, M., Shweder, R. A., & Markus, H. (Eds.). (2008). *Just Schools: Pursuing Equality in Societies of Difference*. New York: Russell Sage Foundation.

National Advisory Committee on Creative and Cultural Education. (1999). All our futures: Creativity, culture and education. Retrieved January 15, 2016 from <http://sirkenrobinson.com/pdf/allourfutures.pdf>

National Assembly of State Arts Agencies. (2006). Critical evidence: How the arts benefit student achievement. Retrieved January 16, 2016 from <http://www.nasaa-arts.org/Publications/critical-evidence.pdf>

Nobori, M. (2012). How the arts unlock the door to learning. Retrieved February 5, 2016 from <http://www.edutopia.org/stw-arts-integration-reform-overview>

Pascual-Leone, A., Amedi, A., Fregni, F., & Merabet, L. B. (2005). The plastic human brain cortex. *Annual Review of Neuroscience*, 28, 377-401. <http://dx.doi.org/10.1146/annurev.neuro.27.070203.144216>

Pippens, B. (2013). Policy brief: Enhancing cultural competency and responsiveness in public education. Retrieved February 8, 2016 from <https://mediaregulationicm.wordpress.com/2014/04/30/policy-brief-enhancing-cultural-competency-responsiveness-in-public-education/>

Robinson, K. (2011). *Out of our minds: Learning to be creative*. West Sussex, UK: Capstone Publishing Ltd.

Sahlberg, P. (2009). Creativity and innovation through lifelong learning. *Lifelong Learning in Europe Journal*, (1), 53-60. Retrieved January 15, 2016 from <https://pasisahlberg.com/wp-content/uploads/2013/01/Creativity-and-innovation-in-LLL-2009.pdf>

Sahlberg, P. (n.d.). The role of education in promoting creativity: Potential barriers and enabling factors. Retrieved January 15, 2016 from <http://www.greenschool.org/wp-content/uploads/2012/03/Pasi-Sahlberg.pdf>

Smith, F. (2009). Why arts education is crucial, and who's doing it best. Retrieved January 15, 2016 from <https://www.edutopia.org/arts-music-curriculum-child-development>

Stokrocki, M. (n.d.) Visual arts and multiliteracies in a digital age. Retrieved January 17, 2016 from <https://arteducators-prod.s3.amazonaws.com/documents/246/2cacfc43-4f91-4b0b-8704-969df8aa90a7.pdf?1451958314>

Walker, T. (2012). The good and bad news about arts education in U.S. schools. Retrieved February 15, 2016 from <http://neatoday.org/2012/04/05/the-good-and-bad-news-about-arts-education-in-u-s-schools-2/>.

Yaron, L. [826LA]. (2016, February 10). Student identity through the arts [Blog post]. Retrieved September 5, 2017 from http://www.huffingtonpost.com/826LA/student-identity-through_b_9202628.html

Zastrow, C. V., & Janc, H. (2004). *Academic atrophy: The condition of the liberal arts in America's public schools*. Washington, D.C.: Council for Basic Education. Retrieved February 18, 2016 from <http://www.sjsu.edu/people/kathie.kratochvil/courses/CA177/s0/AcademicAtrophy.pdf>

Population Model for the Bat Flea *Sternopsylla distincta* (Siphonaptera: Ischnopsyllidae) in Temperate Caves of the Brazilian Free-Tailed Bat *Tadarida brasiliensis* (Mammalia: Chiroptera)

Robert L. Bossard

Bossard Consulting

ABSTRACT

*The population dynamics of the bat flea *Sternopsylla distincta* are not quantitatively known. These fleas parasitize Brazilian free-tailed bats (*Tadarida brasiliensis*) in temperate caves. Using laboratory and field data, I model seasonal population changes. Bat flea populations are predicted to boom when bats arrive in the spring, and immature flea stages quickly reach equilibrium densities after a few days. From June to September, all stages are present, with the most abundant being eggs at 90 per m² of guano. Larvae equilibrate at 20 per m², pupae 1 per m², and adults comprise only 10% of the summer's flea population. When bats depart for southern roosts in the fall, bat flea populations decline, but pupae survive the winter. These results imply that *S. distincta**

overwinters both as pupae (in northern caves) and as adults (in southern roosts). Fleas are important in many caves as climbing ability and phoresy allow fleas to attain bats on ceilings, creating a "flea–feces loop" of cycling biomass. Fleas reach bats by crawling up cave walls, or when adult female bats retrieve fallen, flea-infested pups, or through uncommon earwig phoresy. The model provides baseline predictions enabling comparison with field data and insight into food limitation that appears to regulate bat-flea populations in temperate caves.

Bat fleas (*Sternopsylla distincta*) are important components of many cave ecosystems. The direct impacts of fleas on bats are not well studied but include irritation and blood loss, presumably. Cat flea (*Ctenocephalides felis*) females ingest a blood volume of 13.6 μL per day (Dryden and Gaafar 1991), but no data on bat fleas exists. In addition, it is possible that bat fleas vector pathogens such as *Bartonella* and *Rickettsia* bacteria, or even white-nose fungus (Dietrich et al. 2016, Lučan et al. 2016).

Bat fleas affect other species in addition to bats. Fleas expel egested bat blood with flea feces, which rain down to the cave floor (where bat fleas mate and lay eggs, whether on the bat or on the cave floor, is a question requiring research). Fleas then attain the ceiling where bats roost. This cycle of material forms a "flea–feces loop" that enriches nutrients in the guano. Guano supports communities unique to caves that require conservation (Gnaspini 2005, Iskali and Zhang 2015).

How bat fleas ascend to the ceiling requires investigation, but the statement "There is no way for the fleas to return to the host once they are removed" (Pape 2014) is incorrect. There are several behaviors that allow bat fleas to move from cave floors, where they develop as immatures, to cave ceilings where they parasitize as adults.

First, adult bat fleas quest for bats by walking to the highest point available (negative geotropism), then extending their front legs upward (Elbel et al. 1999). The behavior resembles the questing behavior of many ticks and insects. Bats flying through the cave often brush-up against cave obstacles and could pick up questing fleas. Second, when bat pups fall to the floor, mother bats swoop down and pick them up. Fallen bats are infested with large numbers of bat fleas from the cave floor (Elbel et al. 1999). Third, bat fleas cling to the legs of earwigs (Dermaptera), resulting in phoresy (Hastriter et al. 2017). Fourth, adult fleas are able to walk and climb well (Elbel et al. 1999). Bat flea adults tend to have exceptionally long legs, but a diminished pleural arch

makes them weak jumpers. *S. distincta* larvae are unusual, too, having spatulate setae, but how these are involved with larval movement is unknown (Elbel and Bossard 2007).

Adult bat fleas are rare. From the literature, fewer than 15% of bats are typically infested, averaging only one flea per infested bat: the “distribution of bat fleas is one of the most enigmatic problems in the entire field... Doubtless the rarity of bat fleas in this area is in part attributable to lack of collecting. Even in areas that have been thoroughly investigated, however, these fleas are still uncommon” (Lewis 1964).

In this paper, I describe a model of population dynamics of the bat flea, *S. distincta*, in temperate caves containing roosting Brazilian free-tailed bats (*Tadarida brasiliensis*). The bats immigrate into these caves in the spring from southerly roosts and emigrate in the fall, leaving the fleas in the caves without hosts. The model provides a baseline for comparison with field data if it is eventually collected and offers an insight into factors regulating the numbers of bat fleas.

Materials and Methods

Flea collection

Bat flea (*S. distincta*) eggs, larvae, pupae, and adults were collected from temperate *T. brasiliensis* nursery caves in the Great Basin Desert and Central Mixed Grassland ecoregions of the United States (Elbel et al. 1999). Larvae were fed guano (Elbel and Bossard 2007). Developmental periods (days) and survivorship (%) of each stage (egg: 5 d, 70%; 1st instar larva: 4 d, 90%; 2nd: 2 d, 60%; 3rd: 7 d, 70%; pupa: 28 d, 50%; unfed adult: 18 d, 30%) and number of eggs each female adult bat flea laid per day (one egg per female-day) were estimated from laboratory observations at 20°C (Elbel and Bossard 2007).

Model

The population model is a stage- and age-structured, daily life-table spreadsheet. Each stage is assigned its characteristic developmental period and survivorship from the laboratory estimates.

Model assumptions

1. Bats arrive en masse Julian Day 120 (approximately 1 May) and leave Julian Day 240 (approximately 1 September).

2. When bats arrive, they are immediately infested with fleas at a prevalence of 15% and incidence of one flea per bat (numbers estimated from the literature).
3. The bat population remains constant.
4. Any other bat species that overwinter in the cave are not significant refuges for *S. distincta*.
5. The entire population of bat fleas overwinters as pupae, that is, there is no contribution of fleas on bats returning to the roost in the spring.
6. Any cocooned flea ≤ 28 days old is a pupa and any >28 days old is a teneral adult (an adult that has not left the cocoon).
7. Teneral adults eclose (open) their cocoons whenever bats are present.
8. There is no stochasticity or variance.
9. Temperature in the cave remains constant at 20°C.
10. Mortality happens at the end of each stage.
11. There is no mortality due to food limitation, predation, parasitism, or host-grooming on bat fleas other than what may be already included in the laboratory stage-specific survivorship estimates.

Results

The bat flea population 'booms' when bats arrive in the spring (Figure 1). Densities of immature stages equilibrate quickly because fleas developing into a stage are balanced by fleas aging out of that

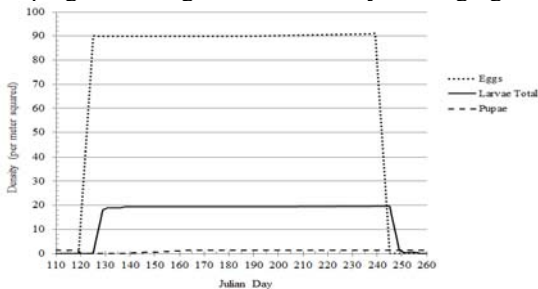


Figure 1. Predicted densities (per m²) of immature bat fleas *S. distincta* in temperate North American caves during the year. Adult densities (not shown) are lower than pupal densities.

stage or dying. The bat flea population declines after bats depart in the fall. During the winter, pupae survive in dormancy.

All stages are present and the immature stages in equilibrium from Julian Days 150 to 240 (approximately 1 June to 1 September). The most abundant stage during the summer is flea eggs, equilibrating at 90 per m² of guano; larvae equilibrate at 20 per m² and pupae at 1 per m². Adults comprise only 10% of the equilibrium summer flea population.

The model predicts that overwintering pupal densities are insufficient to maintain the population.

Discussion

The predicted population dynamics of the model are consistent with observed stage densities, although no quantitative census of immature stages exists, and eggs are too small (millimeter diameter) to be counted easily without a lens (Linley et al. 1994, Elbel et al. 1999). The model does not predict a stable flea population, but nevertheless, fleas are sustained year after year. The discrepancy requires explanation and further refinement of the model.

First, survivorship in the field may be underestimated by the laboratory data used in the model. Immature bat fleas probably require nutrients in fresh guano and blood not the weeks-old guano used to rear the larvae in the laboratory (Elbel and Bossard 2007), although the larvae of many flea species, such as the rat flea *Xenopsylla cheopis*, can survive entirely on organic detritus without the presence of flea feces (Marshall 1981). Second, the assumption that the entire flea population overwinters as pupae may be an oversimplification. At least some *T. brasiliensis* overwinter in dispersed roosts in southern Mexico (Wiederholt et al. 2013), are infested with *S. distincta*, and may inoculate northern caves with fleas.

How do adult fleas on bats continuously know when to reproduce? Bat hormones may trigger flea reproduction, but this has never been investigated (Pearce and O'Shea 2007, Lourenço and Palmeirim 2008).

I conclude from the model results that the population dynamics of *S. distincta* are complicated, with part of its overwintering population being pupae in northern caves and part being adults on migrated bats in southern roosts. Dynamics of bat flea populations are controlled largely by the bats themselves. For the bat flea *S. distincta*, food limitation appears to be the major factor regulating their populations in temperate caves. This is consistent with other cave species. In general, cave ecosystems are food limited (Poulson 2005).

Table 1. Niches of the four genera of bat fleas (Ischnopsyllidae) in temperate North America

Niche characteristics	Fleas on bats that migrate	Fleas on bats that hibernate
Colder-environment fleas	Sternopsylla	Nycteridopsylla
Warmer-environment fleas	Hormopsylla	Myodopsylla

Future research

1. Compare model predictions with field data.
2. Estimate the contribution that adult bat fleas carried to the roost by bats arriving in the spring make to the flea population.
3. Extend model to other temperate bat flea genera in North America (Table 1) (Lewis and Lewis 1994). Comparing *Hormopsylla* (a southern bat flea) with *Nycteridopsylla* (northern) would be of interest.
4. Compare temperate and tropical bat caves. Southern bat caves may lack bat fleas, even though many mites are present (Palacios-Vargas et al. 2011). Mite predation or factors other than food could be limiting bat flea populations in these caves.
5. Measure nutrient cycling in caves with and without bat fleas.
6. Characterize the physiological state of pupae during the winter.
7. Determine triggers and locations for emergence, movement, mating, and oviposition of adult fleas.

Acknowledgment

I thank R. Acosta-Gutiérrez, M.W. Dryden, D. Gettinger, and anonymous reviewers.

References

Dietrich, M., Tjale, M.A., Weyer, J., et al. (2016). Diversity of *Bartonella* and *Rickettsia* spp. in bats and their blood-feeding ectoparasites from South Africa and Swaziland. PLoS ONE 11(3): e0152077. doi:10.1371/journal.pone.0152077

Dryden, M.W., & Gaafar, S.M. (1991). Blood consumption by the cat flea, *Ctenocephalides felis* (Siphonaptera: Pulicidae). *Journal of Medical Entomology* 28(3): 394-400.

Elbel, R.E., & Bossard, R.L. (2007). Observations and larval descriptions of fleas (Siphonaptera: Ceratophyllidae, Ctenophthalmidae, Ichnopsyllidae) of the southern flying squirrel, little brown bat, and Brazilian free-tailed bat (Mammalia: Rodentia, Chiroptera): *Journal of Medical Entomology* 44: 915-922.

Elbel, R.E., Bossard, R.L., Dryden, M.W., Vincent, J.M., & Bradley, P.M. (1999) Observations on the bat fleas, *Myodopsylla insignis* (Rothschild) and *Sternopsylla distincta* (Rothschild). *Journal of the Utah Academy of Science, Arts, and Letters* 76:140-144.

Gnaspini, P. (2005). Guano communities. In Culver, D. C. & White, W. B. (eds.). *Encyclopedia of Caves*. pp. 276-283. Elsevier Academic Press, Amsterdam.

Hastriter, M.W., Miller, K.B., Svenson, G.J., Martin G.J., & Whiting M.F. (2017) New record of a phonetic flea associated with earwigs (Dermaptera, Arixeniidae) and a redescription of the bat flea *Lagaropsylla signata* (Siphonaptera, Ichnopsyllidae). *ZooKeys* 657: 67–79. <https://doi.org/10.3897/zookeys.657.11095>

Iskali, G., & Zhang, Y. (2015). Guano subsidy and the invertebrate community in Bracken Cave: the world's largest colony of bats. *Journal of Cave and Karst Studies* 77(1): 28-36.

Lewis, R.E. (1964). Additional records of fleas from Lebanon, Syria and Jordan. *Proceedings of the Royal Entomological Society London Series A, General Entomology* 39: 157–165.

Lewis, R.E., & Lewis, J.H. (1994). Siphonaptera of North America north of Mexico: Ichnopsyllidae. *Journal of Medical Entomology* 31: 348-368.

Linley, J.R., Benton, A.H., & Day, J.F. (1994). Ultrastructure of the eggs of seven flea species (Siphonaptera). *Journal of Medical Entomology* 31(6): 813-827.

Lourenço, S., & Palmeirim, J.M. (2008). Which factors regulate the reproduction of ectoparasites of temperate-zone cave-dwelling bats? *Parasitology Research* 104: 127-134.

Lučan, R.K., Bandouchova, H., Bartonička, T., Pikula, J., Zahradníková, A., Zukal, J., & Martínková, N. (2016). Ectoparasites may serve as vectors for the white-nose syndrome fungus. *Parasites & Vectors*, 9(1): 16. <https://parasitesandvectors.biomedcentral.com/articles/10.1186/s13071-016-1302-2>.

Marshall, A.G. 1981. *The Ecology of Ectoparasitic Insects*. Academic Press, London.

Palacios-Vargas, J.G., Castaño-Meneses, G., & Estrada, D.A. (2011). Diversity and dynamics of microarthropods from different biotopes of Las Sardinias cave (Mexico). *Subterranean Biology* 9: 113-126. doi: 10.3897/subtbiol.9.2514

Pape, R.B. (2014). Biology and ecology of Bat Cave, Grand Canyon National Park, Arizona. *Journal of Cave and Karst Studies* 76(1): 1–13. doi: 10.4311/2012LSC0266

Pearce, R.D., & O'Shea, T.J. (2007). Ectoparasites in an urban population of big brown bats (*Eptesicus fuscus*) in Colorado. *Journal of Parasitology* 93: 518-530.

Poulson, T.L. (2005). Food sources. Culver, D. C. & White, W. B. (eds.). *Encyclopedia of Caves*. pp. 255-264. Elsevier Academic Press, Amsterdam.

Wiederholt, R., López-Hoffman, L., Cline, J., Medellín, R. A., Cryan, P., Russell, A., McCracken, G., Diffendorfer, J., & Semmens, D. (2013). Moving across the border: modeling migratory bat populations. *Ecosphere* 4(9): 114. <http://dx.doi.org/10.1890/ES13-00023.1>

Kava: An Ethnobotanical Review of *Piper methysticum*

Trevor J. Chamberlain and Olga R. Kopp
Utah Valley University

Abstract

Historically found throughout most of the islands of the Pacific Ocean, Piper methysticum is a shrub cultivated for its rhizomes, which are used in traditional drinks or allopathic treatments. More commonly known as kava, P. methysticum has made its way into western cultures, typically administered as an anxiolytic but occasionally used recreationally. This literature review examines the plant's chemistry and pharmacology, biological activity, clinical studies, contraindications, and current uses in allopathic treatments and complementary alternative medicine. Recent studies have gone into discovering the pharmacology of kavalactone derivations and have found possible uses in the treatment of neurological disorders. Additionally, the biological activity of P. methysticum is believed to occur in the limbic structures of the brain as well as the endocannabinoid system. Current clinical studies have focused on liver toxicity, carcinogenicity, chemoprevention, and applications as an antidepressant. Contraindications include kava dermatopathy and liver toxicity, with leaf extracts showing lower toxicity compared with root

extracts. Furthermore, with recreational and allopathic uses of P. methisticum increasing, the need for research on kava's activity and contraindications is further increased.

Introduction

Piper methysticum is commonly called kava in the United States and Europe, as well as by many various indigenous names (Table 1) throughout the Pacific Islands (Singh & Blumenthal, 1997). “Kava” and other common names from Polynesia usually denote a term similar in meaning to “bitter” (Singh & Blumenthal, 1997; Teschke et al., 2009). Historically found throughout most of the islands in the Pacific Ocean, this plant is a perennial shrub often cultivated for its rhizomes, which are traditionally used to prepare ceremonial drinks or allopathic treatments for a variety of ailments (Teschke et al., 2009; Vallance, 2002). In Europe and the U.S., kava is typically used as an anxiety treatment, which has led to some economic importance, with reports that kava is a multimillion-dollar industry, although the profits are difficult to track (Rex et al., 2002; Showman et al., 2015).

The active compounds in *P. methysticum* are known as kavalactones. Most of these kavalactones are found in the roots, rhizomes, and stumps, with the concentration decreasing in the aerial parts of the plant (Teschke and Lebot, 2011). There are also three piperidine alkaloids found in the leaves and stems that researchers have speculated contribute to impure commercial products and some of the liver toxicity associated with their use (Dragull et al. 2003).

Kavalactones have shown beneficial effects as a treatment for anxiety and depression by binding to gamma-aminobutyric acid (GABA) receptors (Savage et al., 2015). Methysticin, one of the kavalactones, has been found to inhibit the production of NF- κ B proteins; thus, it is believed it may act to prevent certain cancers (Einbond et al., 2017; Shaik et al., 2009; Warmka et al., 2012). Kava has also been found to reduce neuroinflammation and is being examined for its use against neurological disorders (Ketola et al., 2015; Terazawa et al., 2013). However, these compounds may also bind the P450 enzymes of the liver and cause hepatotoxicity (Côté et al., 2004). Major contraindications of kava include hepatotoxicity, and the purity or quality of kava extracts (Showman et al., 2015; Teschke et al., 2011). Currently, the major use in complementary and alternative medicine (CAM) and allopathic treatments is to treat anxiety (Dattilio, 2002; Showman et al., 2015).

Table 1. Names of <i>P. methysticum</i> by country		
Country/ Language	Vernacular Names	Citation
Banks Islands	Gea	Singh and Blumenthal, 1997
English	Kava	Nelson, 2011
Fiji	Yaqona	Nelson, 2011; Singh and Blumenthal, 1997
Hawaii	‘Awa, ‘ava	Nelson, 2011; Singh and Blumenthal, 1997
Kosrae	Seka	Nelson, 2011
Latin	<i>Piper methysticum</i> Forst.	Singh and Blumenthal, 1997
Marquesas	Kava-kava, ‘ava or ‘awa	Nelson, 2011; Singh and Blumenthal, 1997
New Guinea/ Kolepom	Wati	Nelson, 2011
Niue	Kavainu	Nelson, 2011
Papua New Guinea	37+ names such as ka, sika, and saka	Nelson, 2011
Pohnpei	Sakau	Nelson, 2011
Polynesia	Kava, kawa	Nelson, 2011; Singh and Blumenthal, 1997
Samoa	‘Ava ‘ava	Nelson, 2011
Tahiti	‘Ava, ‘ava ‘ava, evava	Nelson, 2011
Tonga	Kava	Vallance, 2002
Torres Islands	Gi	Singh and Blumenthal, 1997
Vanuatu	30+ names such as Maloku, malohu, gea, or gi	Nelson, 2011

Botanical Description

P. methysticum is a shrub (Figure 1) that grows to be between 1.6 m and 3.2 m tall (Nelson, 2011). It can have stems that range in color from dark purple to green and that bear lenticels (pores) for gas exchange. The leaves are shaped like a heart and can grow to be about 13–20 cm long and just as wide (Figure 2). The leaf veins are arranged originating at the base of the blades where there is a 2.5-cm-long petiole. Kava is dioecious and has male and female flowers on different plants with the flowers growing on a spike. The flowers are sterile, however, and propagation of fresh stems is necessary to plant *P. methysticum* (Nelson, 2011).

Kava prefers humid tropical or subtropical climates (Nelson, 2011). The plant needs protection from high winds and soil with adequate drainage to thrive. *P. methysticum* is typically found in shaded areas near streams or at the edges of growth in the forest or clearing. The preferred climate also includes low elevations and plentiful rain. Shade helps the plants in drought and is especially needed for young plants, which are intolerant to dry seasons. The right soil conditions for *P. methysticum* consist of aerated, drainable, fertile soil with heavy organic layers. The soil should be slightly acidic with a pH between 5.5 and 6.5 (Nelson, 2011).



Figure 1. A *P. methysticum* plant (Image source: Forest & Kim Starr, 2009a. Creative Commons Attribution 3.0 License).



Figure 2. Heart-shaped leaves of *P. methysticum* (Image source: Forest & Kim Starr, 2009b. Creative Commons Attribution 3.0 License).

Traditional Uses

There are several traditional uses of *P. methysticum* (Table 2) across multiple cultures. Included in this review are some of the ceremonial, social, and medicinal uses of kava.

Ceremonial and Social Use

Traditionally, *P. methysticum* has been used to prepare a ceremonial drink of the same common name as the plant (i.e., kava). These ceremonies, performed by the peoples of the Pacific islands, are often considered sacred rites (Showman et al., 2015). The ceremony is usually carried out by preparing kava root and rhizome extracts in a large bowl using water or saliva. Smaller cups or bowls are then used by the participants in the ceremony to dip out the drink for consumption (Figure 3).

The kava ceremony is used in many circumstances, both sacred and social. Its use in sacred rites ranges from celebrating meaningful occasions such as births, deaths, or weddings to showing honor to the gods and removing curses (Singh & Blumenthal, 1997). Often, kava could be consumed as a social drink by chieftains and noblemen. Other social uses include welcoming a guest of honor, celebrating achieve-

ments, preparing for a journey, or pronouncing new leadership (Table 2).

Table 2. A summary of the traditional ceremonial, social, and medicinal uses of <i>P. methysticum</i>			
Type of Use	Purpose	Preparation	Citation
Ceremonial	Sacred rite	Kava root and rhizome extracts prepared in a large bowl using water or saliva. Consumed with smaller bowls or cups in a ceremony	Showman et al., 2015; Singh and Blumenthal, 1997
Social	Social drink, celebration of special events, preparation for war	Kava root and rhizome extracts prepared in a large bowl using water or saliva. Consumed with smaller bowls or cups in a ceremony	Singh and Blumenthal, 1997
Medicinal	Treat anxiety, sleep disorders, asthma and rheumatism, weight loss, and urinary tract health	Kava root and rhizome extracts prepared with water or saliva	Singh and Blumenthal, 1997; Sarris et al., 2009
	Treat fevers and venereal diseases	Kava leaves are used in treatment rather than the roots and rhizomes	Singh and Blumenthal, 1997
	Treat headaches	Kava leaves are made into a poultice and placed under the individual	Singh, 2009



Figure 3. A traditional kava ceremony. (Image source: Brian, 2012. <https://creativecommons.org/licenses/by/2.0/legalcode>).

Kava has even been used as tribes prepared for war (Singh & Blumenthal, 1997). In many societies, it has great value in sacred and social ceremonies.

Medicinal Use

The people of the Pacific islands use kava not only for ceremonies but also for other social activities and in traditional medicine. Uses include treatment for anxiety, sleep disorders, asthma and rheumatism, weight loss, and urinary tract health; additionally, the leaves have been used for treating headaches, fevers, and venereal diseases such as gonorrhea or syphilis (Singh & Blumenthal, 1997). For most ailments, a traditional preparation of the beverage from the roots and rhizomes is administered on a regular basis. A poultice is made out of the leaves for headaches and placed under the individual to treat a fever or cold (Singh, 2009).

Chemistry and Pharmacology

There are several active compounds found in different parts of *P. methysticum*. Table 3 summarizes the major compounds found in the rhizomes and leaves of the plant and some of their pharmacological uses.

Table 3. Active compounds of *P. methysticum* and their locations

Active Compound	Type of Compound	Organ	Citation
Demethoxyyangonin; dihydrokavain; dihydromethysticin; kavain; methysticin; yangonin	Kavalactone	Rhizome	Showman et al., 2015
Cepharadione A	Cepharadione alkaloid	Rhizome	Dragull et al., 2003; Jaggy and Achenbach, 1992
1-(<i>m</i> - methoxycinnamoyl)- pyrrolidine; 1- cinnamoylpyrrolidine	Pyrrolidine alkaloid	Rhizome	Achenbach and Karl, 1970; Dragull et al., 2003
3 α ,4 α -epoxy-5 β - pipermethystine; awaine; pipermethystine	Piperidine alkaloid	Leaves	Dragull et al., 2003

Rhizomes

Kavalactones, also referred to as styryl α -pyrones, are the major active compounds found in *P. methysticum* (Dragull et al., 2003). There are 18 different kavalactones, with 6 of them acting as the major components (Showman et al., 2015). These major kavalactones are kavain, yangonin, dihydromethysticin, methysticin, dihydrokavain, and demethoxyyangonin, and they account for 96% of the active substances in kava. These compounds are extracted from the rhizomes of *P. methysticum* and were traditionally made into a drink, but are more recently extracted into ethanol or acetone and consumed in caplet form. Three more compounds, one a cepharadione alkaloid and two pyrrolidine alkaloids, are also found in the rhizomes in minor quantities although their activity is not entirely determined (Dragull et al., 2003).

Leaves

The leaves and stems of *P. methysticum* contain three main alkaloids: pipermethystine, 3 α ,4 α -epoxy-5 β -pipermethystine, and awaine

(Dragull et al., 2003). These compounds are classified as piperidine alkaloids, and they are believed to be present in impure kava extracts that result in hepatotoxicity. Pipermethystine is present in stem peelings and leaves while awaine is found mainly in some of the small leaves. These alkaloids pose potential hazards in commercial preparations where the leaves and stem peelings are used to prepare kava extracts along with the rhizomes (Showman et al., 2015). Dragull et al. (2003) point out that teas made from the leaves of *P. methysticum* are also on the market now. Pipermethystine is especially concerning given that it is now a known cytotoxin (Showman et al., 2015).

Biological Activity

P. methysticum has many compounds that produce different biological effects in the body (Table 4). This review discusses a few of the known biological interactions of kava.

The main site of action of kavalactones is believed to be the limbic structures of the brain (Savage et al., 2015). Anxiolytic properties are believed to be possible by a few mechanisms (Savage et al., 2015): One mechanism is through blocking voltage-gated sodium ion channels, which inhibits the influx of sodium required for neuron depolarization and action potential firing. Additionally, kavalactones may act through reducing neurotransmission by blocking calcium ion channels, which take in calcium and cause neurons to release neurotransmitters required for synaptic transmission. Finally, another mechanism is through increasing the binding of GABA molecules to gamma-aminobutyric acid type A (GABA_A) receptors. These receptors then take up chlorine ions, which reverse the membrane potential of a neuron and prevent firing of action potentials (Savage et al., 2015). These actions are done primarily by kawain and dihydrokawain, resulting in feelings of calmness and numbness when using kava. However, the distinction between the effects of kava and drunkenness comes from other kavalactones inhibiting the reuptake of dopamine. So, the overall effect is calmness, but there is no impairment to cognitive ability (Savage et al., 2015).

Research has indicated that kava metabolizes through and interacts with various cytochrome p450 enzymes. In the liver, there are many cytochrome p450 enzymes which perform most of the body's metabolism of toxins, drugs, food, and carcinogens. Behl et al. (2011) did research that indicates the *CYP1A1* and *CYP1A2* genes that code for metabolic enzymes in the liver are involved in kava metabolism into the blood stream. Another study found that kavalactones appear to

Table 4. The biological activities of compounds in *P. methysticum* and their effects.

Biological Interaction	Kava Compound	Biological Effect	Citation
Neural inhibition through GABA receptor interactions	Kawain and dihydrokawain	Anxiolytic properties through feelings of calmness and numbness.	Savage et al., 2015
Dopamine reuptake inhibition	Kavalactones	Stimulation of neural activity so calmness occurs without cognitive impairment	Savage et al., 2015
CYP1A1 and CYP1A2 interactions	Kavalactones	Metabolism of kavalactones into the blood stream; possible mode of hepatotoxicity	Behl et al., 2011
Inhibition of CYP3A4, CYP1A2, CYP2C9, and CYP2C19	Kavalactones	Possible mode of hepatotoxicity or herb-drug interactions	Côté et al., 2004
Interaction with CB1 receptors of the endocannabinoid pathway	Yangonin	<i>Cannabis</i> -like interactions like bloodshot eyes, increased body temperature, loss of motor function, and relaxation	Ligresti et al., 2012

inhibit CYP3A4, CYP1A2, CYP2C9, and CYP2C19 enzymes (Côté et al., 2004). Interactions with cytochrome p450 enzymes indicate possible modes of toxicity in the liver, or possible routes for herb-drug interactions to occur where hepatic metabolic pathways are shared and may inhibit one another. These findings are explained in more detail later in this article.

The effects of kavalactones that seem to resemble those of *Cannabis* have been studied (Ligresti et al., 2012). These include bloodshot eyes, increased body temperature, loss of motor function, and relaxa-

tion. The possible interaction between kavalactones and the endocannabinoid system was studied using a structure-activity relationship analysis, including 5 natural kavalactones and 9 analogous molecules. The molecule yangonin was the only compound among the kavalactones that was able to bind to the CB1 receptor of the endocannabinoid pathway. The CB1 receptor is the binding site for *Cannabis* that causes its psychoactive effects. Therefore, it is speculated that yangonin might play a role in the psychoactive nature of kavalactones through interactions with the endocannabinoid pathway (Ligresti et al., 2012).

Pharmacology

The structures of kavalactones are used by pharmaceutical companies as templates to design drugs to treat neurological disorders. One study examined the kavalactone-derived compound 2',6'-dichloro-5-methoxymethyl-5,6-dehydrokawain, which showed the ability to prevent the death of neuron cells due to oxidative stress (Tanaka et al., 2010). This oxidative stress is a known factor in diseases such as Alzheimer's and Parkinson's. Findings suggested that the tested compound increased antioxidant response element activity and heme oxygenase 1 (HO-1) protein synthesis (Tanaka et al., 2010). HO-1 was found to reduce neuron cell death induced by hydrogen peroxide, which could have positive implications in treating neurodegenerative disorders. In 2013, 2',6'-dichloro-5-methoxymethyl-5,6-dehydrokawain underwent more tests to examine its ability to reduce neuro-inflammation (Terazawa et al., 2013). The effects of the compound were tested in the Nrf2 signaling pathway to see if it increased production of HO-1. The Nrf2 pathway and HO-1 were then analyzed for their ability to suppress nitric oxide synthase (iNOS) that produces nitric oxide (NO) and contributes to inflammation in neuron cells. Findings in this study suggest that the compound derived from kavalactones does affect the Nrf2 pathway and inhibits the production of NO. Inflammation in neural cells is found in diseases such as Alzheimer's and Parkinson's, and is commonly associated with production of NO (Terazawa et al., 2013). The studies by Tanaka et al. (2010) and Terazawa et al. (2013) indicate that this kavalactone-derived molecule may be important for the treatment of neurological disorders.

Clinical Studies

Because of its many compounds with varying effects, researchers have studied *P. methysticum* for its clinical applications (Table 5). The following section discusses clinical studies in hepatotoxicity, carcinogenicity, chemoprevention, and depression.

Table 5. Clinical studies conducted using <i>P. methysticum</i> and their conclusions		
Area of Study	Biological Site of Interest	Conclusions
Hepatotoxicity and carcinogenicity	CYP1A1A expression	Possible increase in hepatotoxicity and carcinogenicity in the liver (Yamazaki et al., 2008)
Hepatotoxicity	Changes in 42 drug-metabolizing genes, many in the cytochrome P450 family	Possible drug-herb interactions, which may cause build-up of toxins in the liver (Guo et al., 2009)
Hepatotoxicity	CYP1A1 and CYP1A2 interactions	Kava affects these metabolic pathways, which may lead to hepatotoxicity (Behl et al., 2011)
Hepatotoxicity	CYP3A4, CYP1A2, CYP2C9, and CYP2C19	Kava inhibits these metabolic pathways, which may lead to hepatotoxicity or herb-drug interactions (Côté et al., 2004)
Carcinogenicity	L5178Y lymphoma cells	Kava does not appear to cause cancer in L5178Y lymphoma cells (Whittaker et al., 2008)
Carcinogenicity	Dose-dependent effects on mice and rat livers	Increase of hepatoblastomas in male mice and adenoma and carcinoma in low- and mid-dose groups of female mice; kava usage could increase the risk of cancer in humans (Behl et al., 2011)
Chemoprevention	NF- κ B activation	Methysticin inhibited NF- κ B activation in lung cancer tissues. Methysticin and analogous compounds may help prevent cancer (Narayanapillai et al., 2014; Shaik et al., 2009; Warmka et al., 2012)
Chemoprevention	Calcium-MSH-activated B16 melanoma cells	Flavokawains B and C inhibit melanogenesis in MSH-activated B16 melanoma cells. Kava extracts may act in skin cancer prevention (Jeong et al., 2015)
Antidepressant	Individuals with heightened levels of anxiety	Kava was effective in treating depression in addition to being an anxiolytic (Sarris et al., 2009)

Hepatotoxicity and Metabolizing Genes

In 2002, Germany banned the sale of kava products because of reported deaths and liver transplants resulting from its use. Other nations, including the United Kingdom, Switzerland, Canada, Australia, and France, decided to set laws prohibiting the sale of kava (Whittaker et al., 2008). Thus, many of the subsequent studies involving *P. methysticum* examine the toxicology of kava involving the liver. One study found that a gene belonging to the cytochrome p450 family that metabolizes substances foreign to the body may contribute to the hepatotoxicity of kava (Yamazaki et al., 2008). This study found that rats given high doses of kava extract for 8 days and tested using real-time PCR had elevated levels of *CYP1A1* mRNA expression and increased liver weights. The researchers indicated that consumers who use more than the suggested daily amounts of kava could experience increased *CYP1A1* expression, which plays a role in metabolizing chemicals such as drugs and toxins in the liver (Yamazaki et al., 2008). By increasing *CYP1A1* expression, the researchers suspect kava could be both beneficial and harmful to liver tissues. The authors explain that benefits may come through an increased ability to break down harmful toxins and carcinogens while the increased expression of *CYP1A1* itself may contribute to the hepatotoxic nature of *P. methysticum* and that subsequent animal tests would seek to determine the exact effects. Interestingly, kava can potentiate the toxicity induced by over-the-counter drugs such as acetaminophen, a widely used drug, probably by induction of mitochondrial dysfunction (Yang and Salminen, 2011).

Another study found that multiple drug-metabolizing genes and their mechanisms could play a part in kava hepatotoxicity (Guo et al., 2009). Mice were treated with kava extracts through a feeding tube for 14 weeks, and the common gene interactions were identified by DNA microarray analysis. Significant changes in 42 gene pathways were identified, many of which belong to the cytochrome p450 family that metabolizes many substances that are foreign to the body. This study concluded that hepatotoxicity from kava may involve drug-herb interactions through these metabolizing genes (Guo et al., 2009; Teschke et al., 2009). The studies by Behl et al. (2011) and Côté et al. (2004) also describe interactions of kava with other genes in the cytochrome p450 family that could cause drug interactions. These studies suggest that using kava could change the ability or rate of the liver's metabolizing genes involving other drugs, which could then build up in the liver, resulting in toxicity.

Carcinogenicity

Because of the toxic interactions of kava in the liver, studies have been performed to test *P. methysticum* extracts as possible hepatocarcinogens. One study tested kavalactones as possible cancer-causing agents. Two commercially prepared kava supplements were tested alongside six extracted kavalactones for effects on L5178Y lymphoma cells in mice. None of the tested samples demonstrated mutations in the L5178Y synthesis pathway. So, while the kavalactones cause hepatotoxicity, they do not appear to be carcinogenic in these cells (Whittaker et al., 2008). However, other research has suggested that kava extracts may promote cancer. One study examined the dose-dependent effects of kava on the livers in rats and mice (Behl et al., 2011). Long-term effects were tested alongside differing dosages of kava. This study found that male mice had an increase in hepatoblastomas and female mice had elevated rates of adenoma and carcinoma in low- and mid-dose groups. The researchers believed that this was evidence that kava usage could increase the risk of cancer in humans as well, but future studies would have to be conducted to be conclusive (Behl et al., 2011).

Chemoprevention

Studies have provided evidence that kava may have some uses in cancer prevention. Researchers analyzed compounds in kava for their properties in cancer prevention (Einbond et al., 2017; Shaik et al., 2009). Using lung cancer tissues, fractionated compounds were tested for their ability to inhibit nuclear factor κ B (NF- κ B), a transcription factor that can be involved in the onset of cancer. After identifying which fraction inhibited the pathway the most, ^{13}C -NMR spectroscopy was used to pinpoint methysticin as the kavalactone involved in NF- κ B suppression. The researchers asserted that methysticin and other analogous kavalactones may provide an explanation for the cancer-preventive properties of *P. methysticum* (Shaik et al., 2009).

A recent study examined *P. methysticum* as a possible inhibitor of skin cancer (Jeong et al., 2015). This study tested ethanolic extracts of kava roots and found that they inhibited melanin synthesis in MSH-activated B16 melanoma cells. Specifically, the kavalactones known as flavokawains B and C were isolated and identified as the compounds involved in melanogenesis inhibition. Excessive production of melanin has been linked to skin cancer, thus kava extracts may contain natural agents that are effective in skin cancer protection (Jeong et al., 2015).

Antidepressant

Kava is typically used to treat anxiety, but studies have been performed to evaluate its antidepressant effect. A three-week clinical trial for anxiety and depression in a double-blind crossover design was conducted on 60 adults (Sarris et al., 2009). Researchers tested individuals that had experienced heightened levels of anxiety for at least one month. Using the Hamilton Anxiety Scale, Beck Anxiety Inventory, and the Montgomery-Asberg Depression Rating Scale, it was determined that Kava worked as a treatment for anxiety and was also effective for depression following anxiety (Sarris et al., 2009).

Contraindications

Dermopathy

Kava dermopathy is a common side effect of extended kava usage. One study reports that 45% of regular kava users have dermopathy and 75% of heavy users have the symptoms (Hannam et al., 2014). The symptoms of kava dermopathy include a gray, dry, scaly rash on the skin, and sunlight has been known to intensify the symptoms. In Fiji, kava dermopathy is called kanikani and was traditionally viewed as a symbol of privilege because chiefs were typically the largest consumers of kava. The treatment for kava dermopathy is to simply reduce or restrict one's consumption of kava (Hannam et al., 2014), which results in elimination of the symptoms.

Liver Toxicity

As previously mentioned, Germany banned the use of kava in 2002 followed by many European countries, Australia, and Canada (Whittaker et al., 2008). This ban resulted because 10 individuals required liver transplants after using encapsulated kava or solvent extractions (Showman et al., 2015). Two patients were from the U.S., two in Switzerland, and six in Germany. These transplants took place between 1999 and 2002 (Showman et al., 2015). This led to the many studies on hepatotoxicity to understand how safe it is to use kava. As previously described, kava has been found to interact with metabolizing genes and possibly other drugs (Yamazaki et al., 2008; Guo et al., 2009) and is a suspected hepatocarcinogen (Whittaker et al., 2008; Behl et al., 2011). However, some were unsure whether kava itself was the source of toxicity or if it was the solvent extractions and encapsulated forms commonly used in the U.S. and Europe that was creating the danger associated with kava. Research on kava toxicity in human liver was

previously primarily performed on solvent extracts using ethanol and acetone. In 2009, a research team also assessed liver toxicity of traditional kava extracts and kava in mixed herb extractions. Using clinical data from the Council for the International Organizations of Medical Sciences, it was determined that traditional and kava-herb mixtures also led to liver toxicity. Therefore, the kava plant itself is most likely the cause of toxicity (Teschke et al., 2009).

Purity/Quality

In light of the hepatotoxicity of *P. methysticum*, some measures to control the purity and quality of commercial kava products are essential. One study indicated the need for quality control by comparing the contents of 25 commercial kava extracts for toxicity and chemical makeup. The results showed that there was a high amount of variability in the products tested for both composition and toxicity. The researchers assert that kava has become popular enough to warrant heavier research and characterization of the products in the U.S. (Martin et al., 2014). Studies of the use of UV/visible absorbance to assess the quality of commercial kava suggest that this is a good method to distinguish between different types of kava and that colorimetric methods can be used to detect poor-quality raw material (Lebot and Legendre, 2016). The types of kava include “noble,” which provides health benefits and doesn’t have undesirable side effects, “wichmanni,” and “two day,” which can result in health damage (Lhuissier et al., 2017).

In 2011, a six-point plan was suggested to standardize commercial kava products (Teschke et al., 2011; Teschke and Lebot, 2011). The six suggestions are as follows:

- Only noble kava crops that are at least five years old should be used in commercial kava preparation because people that use kava traditionally don’t appear to have the same problems with toxicity. As a precaution, the same cultivar should be used, preferably the noble cultivar Borogu.
- Only peeled rhizomes and roots should be used and not any of the shoots or leaves. Currently, any part of the plant can pass exportation, but other parts of the plant (besides the roots and rhizomes) have a different chemical makeup that could contribute to toxicity.
- Extractions should be performed using water instead of chemical solvents. Studies may show that extraction methods do not affect the toxicity of the kava, but using only aqueous extractions more closely resembles traditional techniques, which are currently believed to be safer for use.

- Dose limitations and treatment duration need to be established. Germany limited kava consumption to 120 mg per day before the 2002 ban while Australia has a maximum limit of 250 mg per day. In vast contrast to these amounts, the daily amount used by island cultures in traditional drinks is 2500 mg. Currently, the safe limit and duration for treatment are unknown and should be determined to provide safe guidelines for kava users.
- Research needs to continue on kava to determine safety thresholds and effectiveness as an anxiolytic.
- Government quality control of commercial kava should be in place and enforced.

Current Use in Allopathic and CAM Therapies

Preparations for CAM Use

Traditionally, kava is consumed as a beverage in cultures of the Pacific Islands. The introduction of kava into western culture has literally taken different forms. Baker (2012) asserts that kava has been “pharmaceuticalized” in western cultures, meaning that it has been taken from its original form and made to more closely resemble pharmaceutical treatments. Kava is now commonly extracted into alcohol or acetone as many other plant extractions are. Often, it is dried, ground, and administered as a pill. Many attempts to chemically isolate compounds from kava also indicate “pharmaceuticalization” (Baker, 2012). Kava now exists in many forms for medicinal use, including liquid extracts, pills, gel-caps, and teabags, and can be purchased at supermarkets, health-food stores, grocery stores, and online (Singh, 2009). At the same time, western cultures also use kava recreationally, in similar ways to alcohol or as a means to attain a “legal high” (Baker, 2012). Recreationally, kava is sometimes consumed similarly to the traditional method by drinking it out of a shared bowl with smaller bowls, although the drink is often consumed on its own. Kava bars have even begun finding their way into western cultures; there patrons can consume kava either by the cup or in a tanoa, the large bowl for large parties. The primary difference with recreational consumption is that the ceremonial context of kava is removed. Both western and Pacific cultures have made shifts towards recreational use of kava (Baker, 2012).

Anxiolytic uses

P. methysticum extracts and capsules are sold as a remedy for anxiety. Kava has been studied alongside other anxiolytics, such as oxazepam and other benzodiazepines, without the unwanted side effects of dizziness, drowsiness, and addiction that often accompany benzodiazepines (Walji, 1997 as cited in Baker, 2012). In pill form, kava has differing amounts per capsule, usually ranging from 100 to 250 mg, and concentrations varying from 30 to 70%. To reach anxiolytic effects similar to oxazepam, the recommended treatment is three 100-mg doses of 70% kavalactone concentration (Bloomfield, 1998 as cited in Baker, 2012).

Discussion

Uses for *P. methysticum* vary from traditional ceremonial beverages to extracts and pills meant to treat anxiety. Kavalactones in the roots and rhizomes have been identified as the primary compounds involved in biological activity in humans. However, in light of several cases of hepatotoxicity, caution and standardization appears to be necessary for safe consumption of kava. Research on kava would be beneficial to understand herb–drug interactions and the exact mode of toxicity. Current allopathic uses are primarily anxiolytic with kava being sold as a supplement to treat anxiety. Recreational uses of kava are also increasing, further increasing the need for research on kava’s contraindications.

References Cited

- Achenbach, H. & Karl, W. (1970). Über die Isolierung von zwei neuen Pyrrolididen aus Rauschpfeffer (*Piper methysticum* Forst). *Organische Chemie*, 103(8), 2535-2540.
- Baker, J. D. (2012). Pills, potions, products: Kava's transformations in new and nontraditional contexts. *Contemp Pacific*, (2), 233.
- Behl, M., Nyska, A., Chhabra, R. S., Travlos, G. S., Fomby, L. M., Sparrow, B. R., et al. (2011). Liver toxicity and carcinogenicity in F344/N rats and B6C3F1 mice exposed to Kava Kava. *Food Chem Toxicol*, 49(11), 2820-2829. <http://dx.doi.org/10.1016/j.fct.2011.07.067>

Brian (Photographer) (2012, June 28). *Kava ceremony on Kadavu* [digital image]. Retrieved from <https://www.flickr.com/photos/bdearth/7499484598/in/faves-146073880@N02/>

Côté, C. S., Kor, C., Cohen, J., & Auclair, K. (2004). Composition and biological activity of traditional and commercial kava extracts. *Biochem Biophys Res Commun*, 322(1), 147-152. <http://dx.doi.org/10.1016/j.bbrc.2004.07.093>

Dattilio, F.M. (2002). The use of Kava and cognitive-behavior therapy in the treatment of panic disorder. *Cogn Behav Pract*, 9, 83-88.

Dragull, K., Yoshida, W. Y., & Tang, C. (2003). Piperidine alkaloids from *P. methysticum*. *Phytochemistry*, 63(2), 193-198. [http://dx.doi.org/10.1016/S0031-9422\(03\)00111-0](http://dx.doi.org/10.1016/S0031-9422(03)00111-0)

Einbond, L.S., Negrin, A., Kulakowski, D.M., Wu, H.A., Antonetti, V., Jalees, F., et al. (2017). Traditional preparations of kava (*Piper methysticum*) inhibit the growth of human colon cancer cells in vitro. *Phytomedicine*, 24, 1-13.

Forest & Kim Starr (Photographer) (2009a, November 4). *starr-091104-1007-Piper_methysticum-habit-Kahanu_Gardens_NTBG_Kaeleku_Hana-Maui* [digital image]. Retrieved from <https://www.flickr.com/photos/starr-environmental/24691836230/in/faves-146073880@N02/>.

Forest & Kim Starr (Photographer) (2009b, November 4). *starr-091104-8926-Piper_methysticum-leaves-Kahanu_Gardens_NTBG_Kaeleku_Hana-Maui* [digital image]. Retrieved from <https://www.flickr.com/photos/starr-environmental/24692827800/in/faves-146073880@N02/>

Guo, L., Shi, Q., Dial, S., Xia, Q., Mei, N., Li, Q., et al. (2009). Gene expression profiling in male B6C3F1 mouse livers exposed to kava identifies—Changes in drug metabolizing genes and potential mechanisms linked to kava toxicity. *Food Chem Toxicol*, 48(2), 686-696. <http://dx.doi.org/10.1016/j.fct.2009.11.050>

Jaggy, H. & Achenbach, H. (1992). Cephadione A from *Piper methysticum*. *Planta Med*, 58(1), 111.

Jeong, H., Lee, C. S., Choi, J., Hong, Y. D., Shin, S. S., Park, J. S., et al. (2015). Flavokawains B and C, melanogenesis inhibitors, isolated from the root of *Piper methysticum* and synthesis of analogs. *Bioorg Med Chem Lett*, 25(4), 799-802. <http://dx.doi.org/10.1016/j.bmcl.2014.12.082>

Hannam, S., Murray, M., Romani, L., Tuicakau, M., & J Whitfeld, M. (2014). Kava dermatopathy in Fiji: an acquired ichthyosis? *International J Dermatol* 53(12), 1490-1494. doi:10.1111/ijd.12546

Ketola, R. A., Viinamäki, J., Rasanen, I., Pelander, A., & Goebeler, S. (2015). Fatal kavalactone intoxication by suicidal intravenous injection. *Forensic Sci Int*, 249, e7-e11. <http://dx.doi.org/10.1016/j.forsciint.2015.01.032>

Lebot, V. & Legendre, L. (2016). Comparison of kava (*Piper methysticum* Forst.) varieties by UV absorbance of acetonic extracts and high-performance thin-layer chromatography. *J Food Comp Anal* 48, 25-33.

Lhuissier, T., Mercier, P.E., Michalet, S., Lebot, V. & Legendre, L. (2017). Colorimetric assessment of kava (*Piper methysticum* Forst.) Quality. *J Food Comp Anal*, 59: 27-34.

Ligresti, A., Villano, R., Allarà, M., Ujváry, I., & Di Marzo, V. (2012). Kavalactones and the endocannabinoid system: The plant-derived yanonin is a novel CB1 receptor ligand. *Pharmacol Res*, 66(2), 163-169. <http://dx.doi.org/10.1016/j.phrs.2012.04.003>

Lüde, S., Török, M., Dieterle, S., Jäggi, R., Bütter, K.B. & Krähenbühl, S. (2008). Hepatocellular toxicity of kava leaf and root extracts. *Phytomedicine*, 15, 120-131.

Martin, A. C., Johnston, E., Xing, C., & Hegeman, A. D. (2014). Measuring the chemical and cytotoxic variability of commercially available kava (*P. methysticum* G. Forster). *Plos ONE*, 9(11), 1-7. doi:10.1371/journal.pone.0111572.

Narayanapillai, S.C., Balbo, S., Lietzan, P., Gill, A.E., Upadhyaya, P., Shaik, A.A., et al. (2014). Dihydromethysticin from kava blocks tobacco carcinogen 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone-induced lung tumorigenesis and differentially reduces DNA damage in A/J mice. *Carcinogenesis* 10, 2365-2372.

Nelson, S. C. (2011). Farm and forestry production and marketing profile for kava (*P. methysticum*). In Elevitch, C.R. (ed.). Specialty crops for Pacific Island agroforestry. *Permanent Agriculture Resources (PAR)*, Holualoa, Hawai'i. <http://agroforestry.net/scps>

Rex, A., Morgenstern, E & Fink, H. (2002). Anxiolytic-like effects of Kava-Kava in the elevated plus maze test—a comparison with diazepam. *Prog Neuro-Psychopharmacol Biol Psychiatry*, 26: 855-860.

Sarris, J., Kavanagh, D. J., Byrne, G., Bone, K. M., Adams, J., & Deed, G. (2009). The kava anxiety depression spectrum study (KADSS): a randomized, placebo-controlled crossover trial using an aqueous extract of *P. methysticum*. *Psychopharmacology*, 205(3), 399-407.

Savage, K. M., Stough, C. K., Byrne, G. J., Scholey, A., Bousman, C., Murphy, J., et al. (2015). Kava for the treatment of generalised anxiety disorder (K-GAD): study protocol for a randomized controlled trial. *Trials*, 16, 493. <http://doi.org/10.1186/s13063-015-0986-5>

Shaik, A. A., Hermanson, D. L., & Xing, C. (2009). Identification of methysticin as a potent and non-toxic NF- κ B inhibitor from kava, potentially responsible for kava's chemopreventive activity. *Bioorg Med Chem Lett*, 19(19), 5732-5736. <http://dx.doi.org/10.1016/j.bmcl.2009.08.003>

Showman, A. F., Baker, J. D., Linares, C., Naeole, C. K., Borris, R., Johnston, E., et al. (2015). Contemporary Pacific and Western perspectives on `awa (*P. methysticum*) toxicology. *Fitoterapia*, 100, 56-67. <http://dx.doi.org/10.1016/j.fitote.2014.11.012>

Singh, Y. N. (2009). Kava: An old drug in a new world. *Cultural Critique*, (71), 107–128.

Singh, Y. N., & Blumenthal, M. (1997). Kava: An overview. *Herbalgram*, (39), 33.

Tanaka, A., Hamada, N., Fujita, Y., Itoh, T., Nozawa, Y., Inuma, M., & Ito, M. (2010). A novel kavalactone derivative protects against H₂O₂-induced PC12 cell death via Nrf2/ARE activation. *Bioorg Med Chem*, 18(9), 3133-3139. <http://dx.doi.org/10.1016/j.bmc.2010.03.034>

Terazawa, R., Akimoto, N., Kato, T., Itoh, T., Fujita, Y., Hamada, N., et al. (2013). A kavalactone derivative inhibits lipopolysaccharide-

stimulated iNOS induction and NO production through activation of Nrf2 signaling in BV2 microglial cells. *Pharmacol Res*, 71, 34-43. <http://dx.doi.org/10.1016/j.phrs.2013.02.002>

Teschke, R. & Lebot, V. (2011). Proposal for a Kava quality standardization code. *Food Chem Toxicol*, 49, 2503-2516.

Teschke, R., Genthner, A., & Wolff, A. (2009). Kava hepatotoxicity: Comparison of aqueous, ethanolic, acetic kava extracts and kava-herbs mixtures. *J Ethnopharmacol*, 123(3), 378-384. <http://dx.doi.org/10.1016/j.jep.2009.03.038>

Teschke, R., Sarris, J., & Lebot, V. (2011). Kava hepatotoxicity solution: A six-point plan for new kava standardization. *Phytomedicine*, 18(2-3), 96-103. <http://dx.doi.org/10.1016/j.phymed.2010.10.002>

Vallance, A. K. (2002). Kava Tonga. *J Altern Complement Med*, 8(3), 231-235. doi:10.1089/10755530260127934

Warmka, J.K., Solberg, E.L., Zeliadt, N.A., Srinivasan, B., Charlson, A.T., Xing, C. et al. 2012. Inhibition of mitogen activated protein kinases increases the sensitivity of A549 lung cancer cells to the cytotoxicity induced by a kava chalcone analog. *Biochem Biophys Res Commun*, 424: 488-492.

Whittaker, P., Clarke, J. J., San, R. H. C., Betz, J. M., Seifried, H. E., de Jager, L. S., et al. (2008). Evaluation of commercial kava extracts and kavalactone standards for mutagenicity and toxicity using the mammalian cell gene mutation assay in L5178Y mouse lymphoma cells. *Food Chem Toxicol*, 46(1), 168-174. <http://dx.doi.org/10.1016/j.fct.2007.07.013>

Yamazaki, Y., Hashida, H., Arita, A., Hamaguchi, K., & Shimura, F. (2008). High dose of commercial products of kava (*Piper methysticum*) markedly enhanced hepatic cytochrome P450 1A1 mRNA expression with liver enlargement in rats. *Food Chem Toxicol*, 46(12), 3732-3738. <http://dx.doi.org/10.1016/j.fct.2008.09.052>

Yang, X. & Salminen, W.F. 2011. Kava extract, an herbal alternative for anxiety relief, potentiates acetaminophen-induced cytotoxicity in rat hepatic cells. *Phytomedicine*, 18, 592-600.

Identification and Characterization of a New *Bacillus* Species

Adriana M. Hall,¹ Donald H. Warner,¹ and Brent Hunt²

¹Dixie State University; ²Soft Cell Biological Research

ABSTRACT

A new Bacillus strain or species isolated from a human blood specimen was studied by phenotypic, chemotaxonomic, and genetic characterizations. This bacterium has phenotypic and chemotaxonomic characteristics similar with those of Bacillus licheniformis and may be a new strain of this species; however, 16S rRNA gene sequencing indicates the bacterium may be a new species. This bacterium has adapted to exist in both the classic and the L-form configuration. Some antibiotics treat bacterial infections by affecting cell wall synthesis of the bacteria present, but this novel bacterium does not have a cell wall in the L-form configuration. This adaptation has potential physiological benefits to the bacterium including, but not limited to, resistance to various antibiotics.

INTRODUCTION

Bacteria within the phylum *Firmicutes* genus *Bacillus* are rod-shaped, endospore-producing, gram-positive organisms, all of which are obligate aerobes or facultative anaerobes. Many of these are common soil bacteria, although some are associated with disease. Two members of this genus, *Bacillus licheniformis* and *Bacillus subtilis*, are motile, facultative anaerobes found in soils and grow in neutral or alkaline conditions (Takami et al., 2000). *B. licheniformis* produces toxins associated with human diseases (e.g., food poisoning) and toxins that inhibit the function of mammalian sperm flagella (Salkinoja-Salonen et al., 1999). In addition to the toxin production in *B. licheniformis* strains, the bacteria produce degradable bioflocculants that are used industrially to manufacture enzymes, antibiotics, and chemicals that aid in environmental nutrient cycling (Rey et al., 2004). *B. subtilis* can also potentially cause infections in humans, specifically in an abscess, the respiratory tract, and the urinary tract (Turnbull, 1996).

L-form or CWD (cell wall-deficient) is a term for bacteria that are able to shed their cell wall, after which they can only survive in an isotonic supportive environment that compensates for the loss of protection provided by a cell wall. The lack of a cell wall makes detection of the bacteria by staining difficult (Dienes, 1970), and occasional successes generally have not been verifiable by other laboratories (Allan et al., 2009), which causes some researchers to be skeptical of the existence of these bacteria when the bacteria are in the L-form configuration.

Here we describe a previously unknown *Bacillus* species, similar genetically and phenotypically to *B. licheniformis* and *B. subtilis*, that was isolated as an L-form bacterium from a human blood sample. To analyze this new *Bacillus* species, we subjected it to standard genetic, chemotaxonomic, phenotypic, and antibiotic sensitivity tests.

METHODS

Isolation and Culture

The bacteria were initially isolated in the L-form configuration from a blood sample. A drop of blood was aseptically collected by a finger lance from a 57-year-old man with a history of chronic anemia. The blood drop was incubated in a vial of brain–heart infusion broth (Carolina Biological Supply) without agitation for 14 days at room temperature. Aliquots from the vial were then transferred to two media plates of brain–heart infusion agar. Aliquots were covered quickly with

sterile glass coverslips to stabilize osmolarity since L-form bacteria need an isotonic environment. One plate was then incubated aerobically, and another anaerobically, at 37°C for 48 hours, and then at room temperature for periods up to 10 weeks. The long incubation times were necessary for the L-form bacteria to convert to classic-form bacteria with cell walls. Colonies were then transferred aseptically to blood agar plates (Tryptic Soy Agarose + 5% sheep red cells, Hardy Diagnostics) and incubated at 37°C until new colonies of sufficient size were formed to allow extraction and sequencing of 16S ribosomal RNA.

Genetic Testing

Total DNA extractions from agar plates were performed using PrepMan Ultra sample preparation reagent. Total DNA extractions were then diluted to 1:50 using Millipore water (Millipore RiOs 16) and stored at 0°C. Initial PCR on samples was performed using the MicroSEQ 500 16S rDNA PCR kit on a GeneAmp 9700 PCR system in 9600 emulation mode following a reaction volume optimized version of the MicroSEQ 500 16S rDNA Identification protocol. Verification of initial PCR success was performed using 2.2% Agarose FlashGel DNA Cassettes (Lonza FlashGel system). Verified samples were cleaned using HT ExoSAP-IT (Affymetrix USB) and cycle sequenced using a MicroSEQ 500 16S rDNA Sequencing Kit and a reaction volume optimized version of the MicroSEQ 500 16S rDNA Identification protocol.

Cycle sequencing products were cleaned and dried using a modified version of the BigDye Terminator v1.1 Cycle Sequencing Kit's Ethanol/EDTA/ Sodium Acetate precipitation protocol. Samples were prepared and Sanger Sequenced on a Long Ranger Polyacrylamide gel (Lonza) using an ABI Prism 377-96 DNA Sequencer (Applied Biosystems) with a BigDye v3.1 Matrix tracking file according to the manufacturer's instructions.

Subsequent sequence trimming and contiguous sequence assembly was performed using Sequencher DNA Sequence Analysis Software (Gene Codes Corporation). Contiguous sequences were then compared against the publicly available 16S ribosomal RNA (Bacteria and Archaea) database using NCBI BLASTn (National Center for Biotechnology Information).

Phenotypic Testing

Shape and cell wall configuration were analyzed through microscopic examination following gram staining. To find the optimal temperature at which the bacteria grow, they were inoculated into three sets

of six test tubes each and incubated at three different temperatures (25°C, 30°C, 35°C). The mobility of the bacteria was tested by stab inoculation of a motility medium (Carolina Biological Supply) with 0.05 g/liter triphenyltetrazolium chloride added as a color indicator. Endospore production was determined by culturing cells for two days in tryptic soy broth (Carolina Biological Supply) and performing microscopic analysis following primary stain with 1% malachite green hydrochloride (Carolina Biological Supply) and secondary stain with safranin (Carolina Biological Supply).

Chemotaxonomic Testing

Tests for oxygen utilization enzymes and a test to analyze the use of oxygen by the bacterium were performed. The oxidase test was used to determine the presence of cytochrome c oxidase enzyme. A catalase test was used to determine the presence of catalase enzyme. A fluid thioglycollate (Carolina Biological Supply) test was conducted to measure oxygen utilization.

Because the bacteria were obtained from an adult male having chronic anemia, a hemolysis test on blood agar plates (Tryptic Soy Agarose + 5% sheep red cells, Hardy Diagnostics) was conducted to observe the effects of any metabolic enzymes or toxins present that lyse red blood cells. To analyze more metabolic enzymes present in the bacteria and the pH conditions at which the bacteria can grow, we also inoculated a microtiter plate (GEN III MicroPlate, Biolog, Inc.).

Antibiotic Testing

Two antibiotics, penicillin and vancomycin, were used to test for conversion of classic to L-form configuration. Bacteria were exposed to the antibiotics on live slides while the bacteria were in the classic-form configuration. The bacteria were analyzed at day one and day three of exposure to each antibiotic for L-form formation.

RESULTS

Genetic Results

The 16S rRNA gene sequence of the new bacterial isolate was 98.4% similar to that of *B. licheniformis* (Table 1) and 98% similar to *B. subtilis* (data not shown).

Table 1. 16s-rRNA gene sequence comparison of unknown bacteria with *B. licheniformis*

Sample Z-879 D-56-B-PCN 98.4% SC-

65 68 84 86 89 96 278
C4A C4T T4G G4T C4G C4T G4A

Bacillus licheniformis strain DSM 13 16S ribosomal RNA gene, complete sequence
Sequence ID: NR_118996.1 Length: 1545 Number of Matches: 1
Related Information
<pre> <@aln_gene_info@> </pre>
Range 1: 34 to 499 GenBankGraphics
Next Match:
Previous Match:

Alignment statistics for match #1

Score	Expect	Identities	Gaps	Strand
822 bits(445)	0.0	459/466(98%)	0/466(0%)	Plus/Plus
Query 1	GGCGTGCCTAATACATGCAAGTCGAGCGGACGATGGGAGCTTGCCTCCCTGATGTGAGCG			60
Sbjct 34	GGCGTGCCTAATACATGCAAGTCGAGCGGACGAGCGGGAGCTTGCCTCCCTAGGTGAGCG			93
Query 61	GCGGACGGGTGAGTAACACGTTGGGTAACCTGCCTGTAAGACTGGGATAACTCCGGGAAAC			120
Sbjct 94	GCGGACGGGTGAGTAACACGTTGGGTAACCTGCCTGTAAGACTGGGATAACTCCGGGAAAC			153
Query 121	CGGGGCTAATACCGGATGCTTGATTGAACCGCATGGTTCATATATAAAAGTGGCTTTTA			180
Sbjct 154	CGGGGCTAATACCGGATGCTTGATTGAACCGCATGGTTCATATATAAAAGTGGCTTTTA			213
Query 181	GCTACCACTTACAGATGGACCCGCGCGCATTAGCTAGTTGGTGGAGTAACGGCTCACCA			240
Sbjct 214	GCTACCACTTACAGATGGACCCGCGCGCATTAGCTAGTTGGTGGAGTAACGGCTCACCA			273
Query 241	AGGCACCGATGCGTAGCCGACCTGAGAGGGTATCGGGCACACTGGGACTGAGACACGGC			300
Sbjct 274	AGGCACCGATGCGTAGCCGACCTGAGAGGGTATCGGGCACACTGGGACTGAGACACGGC			333
Query 301	CCAGACTCCTACGGGAGGCAGCAGTAGGGAATCTTCCGCAATGGACGAAAGTCTGACGGGA			360
Sbjct 334	CCAGACTCCTACGGGAGGCAGCAGTAGGGAATCTTCCGCAATGGACGAAAGTCTGACGGGA			393
Query 361	GCAACGCCGCGTGAGTGATGAAGTTTTTCGGATCGTAAAACCTCTGTTGTAGGGAAGAAC			420
Sbjct 394	GCAACGCCGCGTGAGTGATGAAGTTTTTCGGATCGTAAAACCTCTGTTGTAGGGAAGAAC			453
Query 421	AAGTACCGTTCGAATAGGGCGGTACCTTGACGGTACCTAACCCAGAA 466			
Sbjct 454	AAGTACCGTTCGAATAGGGCGGTACCTTGACGGTACCTAACCCAGAA 499			

Phenotypic Results

The bacteria are rod shaped and stain gram positive (Fig. 1). The bacterial size is approximately 1 µm in width × 3–4 µm in length. The bacteria grow best at 35°C. The bacteria are motile as observed by the red growth outward from the inoculation line in the motility medium (Fig. 2). The endospore stain demonstrated the production of endospores like all other bacteria in this genus (data not shown).

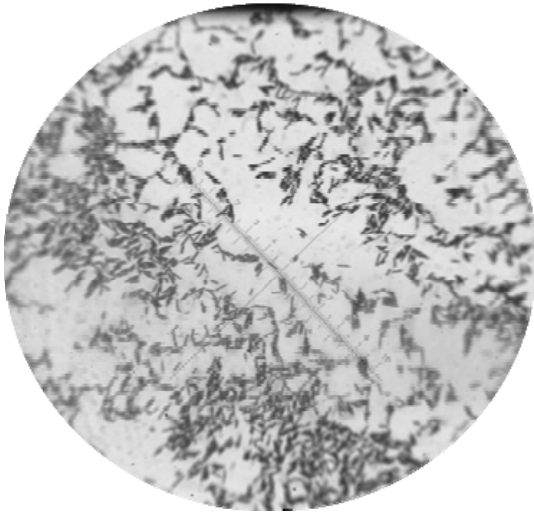


Figure 1. A bifocal microscope photograph of the new *Bacillus* species shown with a gram stain.



Figure 2. A visual of the motility of the bacteria spreading outside the inoculation stab line. Red coloring is due to the 0.05 g/liter triphenyltetrazolium chloride color indicator.

Chemotaxonomic Results

The isolate was oxidase negative (data not shown) and catalase positive (Fig. 3). The fluid thioglycollate medium test confirmed that the new *Bacillus* species are facultative anaerobes (data not shown). The new bacterial isolate can lyse red blood cells (Fig. 4). The micro-titer plate analysis showed that the bacteria can use more sugars as nutrients than *B. licheniformis* and *B. subtilis* (Table 2). The new bacterial isolate can grow at lower pH levels than human physiological pH of 7.4. The bacteria grew well at pH 6 and even exhibited some growth at pH 5 (Fig. 5).

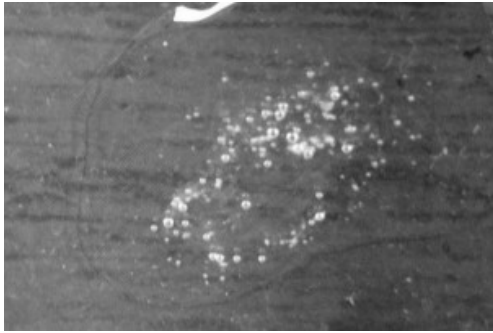


Figure 3. Results of catalase test shown by bubbling of the inoculate in the presence of H_2O_2 .

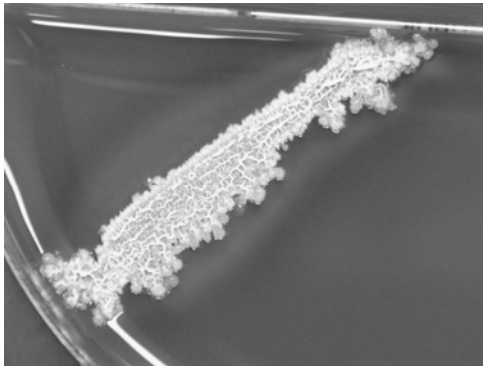
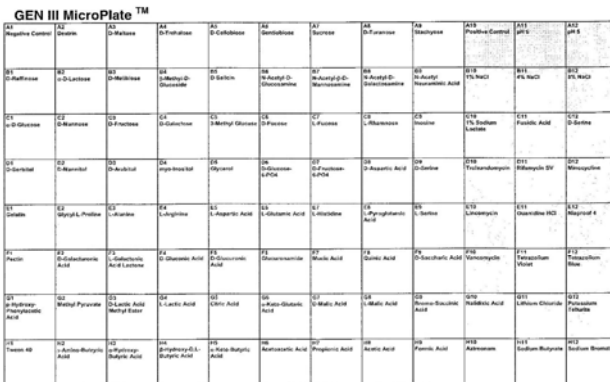


Figure 4. The new bacterial isolate can lyse red blood cells as visualized by the clearing around the bacteria growth on the blood agar demonstrating beta-hemolysis.

Table 2. Phenotypic results of the new *Bacillus* species compared with *B. licheniformis* and *B. subtilis*

Test	Isolates		
	New <i>Bacillus</i> species	<i>Bacillus licheniformis</i>	<i>Bacillus subtilis</i>
Oxidase	NEG	NEG	POS
Catalase	POS	POS	POS
D-raffinose	POS	POS	NEG
Formic acid	POS	NEG	POS
Stachyose	POS	NEG	NEG
Methyl pyruvate	POS	NEG	NEG



Result Comment Notice
Species ID: *Bacillus licheniformis*

Rank	PROB	SIM	DIST	Organism Type	Species
1	0.624	0.624	6.395	GP-Rod-SB	<i>Bacillus licheniformis</i>
2	0.115	0.115	6.215	GP-Rod-SB	<i>Bacillus sporotermis</i>
3	0.094	0.094	6.390	GP-Rod-SB	<i>Bacillus mojavensis/subtilis</i>
4	0.092	0.092	6.408	GP-Rod-SB	<i>Bacillus atrophaeus/subtilis</i>

Key: <: positive, x: negative, <=: mismatched positive, x=: mismatched negative, {x: borderline, -x: less than A1 well

Well Color Values

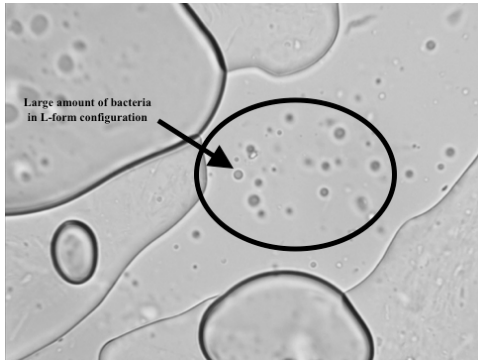
Plate	1	2	3	4	5	6	7	8	9	10	11	12
A	0	< 250	< 250	< 250	< 250	< 250	< 250	[75	{ 75	< 250	< 250	{ 75
B	{ 75	{ 75	0	< 250	< 250	< 250	0	0	0	< 250	< 250	< 250
C	< 250	< 250	< 250	{ 75	0	0	0	{ 75	{ 75	< 250	0	0
D	< 250	< 250	0	< 250	< 250	0	{ 75	{ 75	0	0	0	0
E	{ 75 +	0	{ 75	{ 75	{ 75	{ 75	0	{ 75	{ 75	{ 75	< 250	0
F	< 250	< 250	{ 75	< 250	{ 75	{ 75	{ 75	0	{ 75	0	0	0
G	0	{ 75	0	< 250	{ 75 +	{ 75	0	< 250	{ 75	0	< 250	< 250
H	{ 75	{ 75	0	0	0	{ 75	0	{ 75	< 250	< 250	< 250	0

Report Date Jan 28 2016 4:29 PM

Figure 5. Biolog GEN III MicroPlate phenotypic results of unknown bacteria in comparison to known bacterial species.

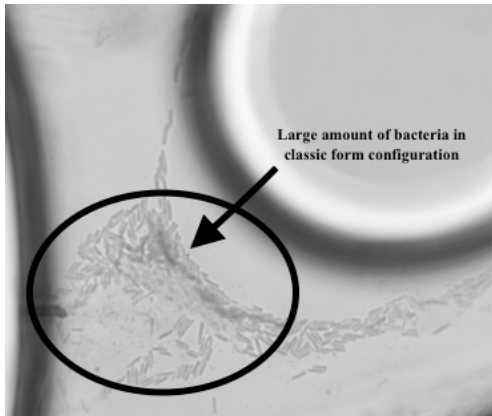
Antibiotic Testing

Results showed classic-form bacteria reverting to the L-form configuration in the presence of penicillin after three days of exposure. During the first day, the classic-form bacteria began to form biofilms with minimum L-form configuration bacteria present. After the third day of exposure, there was presence of heavy biofilm growth as well as a larger amount of L-form configuration bacteria present (Fig. 6). As for the vancomycin resistivity, the bacteria had a large amount in classic-form configuration and a small amount in the L-form configuration after three days (Fig. 7).



Large amount of bacteria in L-form configuration

Figure 6. L-form bacteria viewed by phase contrast microscopy after exposure to penicillin for three days.



Large amount of bacteria in classic form configuration

Figure 7. Classic rod-shaped bacteria configuration viewed by phase contrast microscopy after exposure to vancomycin for three days.

DISCUSSION

Genetic Interpretation

The new *Bacillus* isolate is 98.4% similar to *B. licheniformis* and 98% similar to *B. subtilis* according to the 16S rRNA gene sequence. One definition of separate species in bacteria corresponds to less than 97% 16S rRNA sequence identity (Stackebrandt and Goebel, 1994). Since the new *Bacillus* species shows only 2% or less difference in its 16S rRNA sequence than *B. licheniformis* and *B. subtilis*, it may be just a separate strain of one of these two species or it may be a separate species. Further genetic tests on other gene sequences needs to be conducted to further differentiate the new *Bacillus* species from *B. licheniformis* and *B. subtilis*. Amplification and sequencing of the *gryB* gene and the *rpoB* gene specifically would help pinpoint the phylogenetic position of the bacterial isolate (Drancourt and Raoult, 2005).

Phenotypic Interpretation

The gram-positive cell wall (Fig. 1), facultative growth, and the presence of endospores are characteristics of many *Bacillus* species; therefore, the new bacterial isolate was compared with similar species in the *Bacillus* genus. The motility of the new *Bacillus* bacterium narrowed the search for sister taxon because not all *Bacillus* species are motile (Clearly, Miller, and Martinez 2002).

Chemotaxonomic Interpretation

B. subtilis has the cytochrome c enzyme that uses oxygen as an electron acceptor, whereas *B. licheniformis* and the new *Bacillus* species do not. All three of the bacteria contain the catalase enzyme (Table 2) aiding them in the breakdown of reactive oxygen species. To further solidify this close relationship, the results from the fluid thioglycollate medium test showed all three species as facultative anaerobes (data not shown). The hemolysis of the blood agar further narrowed the search for sister taxon because not all *Bacillus* species are β -hemolytic (Papa-paraskevas et al., 2004).

To identify which of the two known bacteria is closer phenotypically to the new bacterial isolate, a Biolog Gen III multi-test microtiter plate was inoculated for all three bacteria and results were used for comparison (Fig. 5). Two of the test results in the microtiter plate differentiate the new *Bacillus* isolate from the two known bacteria (Table 2). These test results showed the presence of enzymes in the new bacterial isolate that use D-raffinose for an energy source and formic acid as

a carbon source. *B. licheniformis* and the new *Bacillus* isolate share the enzyme to breakdown D-raffinose for energy, whereas *B. subtilis* does not. *B. subtilis* and the new *Bacillus* isolate share a different enzyme that breaks down formic acid for a carbon source, whereas *B. licheniformis* does not. This comparison did not show a closer phenotypic relationship to either *B. licheniformis* or *B. subtilis* because the new *Bacillus* isolate has enzymes found in both known bacteria. However, two other tests showed enzymes present in the new *Bacillus* isolate but not in *B. licheniformis* or *B. subtilis* (Table 2, Fig. 5). The new *Bacillus* isolate contains an enzyme that breaks down stachyose for energy and another enzyme that breaks down methyl pyruvate for a carbon source. These results not only differentiate the new *Bacillus* isolate from *B. licheniformis* and *B. subtilis* but clearly show that further testing needs to be done. The similarity of the 16S rRNA gene sequence narrowed the search for the sister taxon, but with the two enzymes the new *Bacillus* isolate has, the percent of similarity among the three bacteria needs to be further analyzed through phenotypic and genotypic testing.

Antibiotic Interpretation

With the adaptation of reverting to the L-form configuration in the presence of some antibiotics, this bacterium has potential physiological benefits including, but not limited to, resistance to various antibiotics (Errington et. al, 2016). By not having a cell wall in the L-form, the bacterium is able to survive after the antibiotic has run its course. The adaptation of no longer containing a cell wall while in the human blood could be a result of the 1.6% difference in the 16S rRNA gene sequence between the new *Bacillus* species and *B. licheniformis*.

Further Research

Further genotypic, phenotypic, chemotaxonomic, and antibiotic testing is needed to solidify the identity of the new *Bacillus* bacterial isolate as a new strain of *B. licheniformis* or *B. subtilis* or as a new separate species.

ACKNOWLEDGMENTS

We acknowledge Jesus Soto for assisting with the antibiotic testing. We thank Dixie State University for the supplies to carry out the research project.

REFERENCES CITED

- Allan, E. J., Hoischen, C., Gumpert, J. (2009). Bacterial L-forms. *Adv Appl Microbiol* 68, 1–39.
- Cleary, T., Miller, N., Martinez, O. V. (2002). Evaluation of wet-prep motility test for presumptive identification of *Bacillus* species. *J Clin Microbiol* 40(2), 730–730. doi:10.1128/jcm.40.2.730.2002
- Dienes, L. Biology and morphology of L forms with a note on the relation of L forms to mycoplasmas. In: Sharp, J. T., ed. *The Role of Mycoplasmas and L Forms of Bacteria in Disease* (Springfield, IL: Charles C. Thomas, 1970), pp. 285–312.
- Drancourt, M., & Raoult, D. (2005). Sequence-based identification of new bacteria: a proposition for creation of an orphan bacterium repository. *J Clin Microbiol* 43(9), 4311–4315. doi:10.1128/jcm.43.9.4311-4315.2005
- Errington J, Mickiewicz K, Kawai Y, Wu LJ. (2016). L-form bacteria, chronic diseases and the origins of life. *Phil Trans R Soc B* 371, 20150494. <http://dx.doi.org/10.1098/rstb.2015.0494>
- Papaparaskevas, J., Houhoula, D. P., Papadimitriou, M., Saroglou, G., Legakis, N. J., Zerva, L. (2004). Ruling out *Bacillus anthracis*. *Emerg Infect Dis* 10(4), 732–735. doi:10.3201/eid1004.030544
- Rey, M. W., Ramaiya, P., Nelson, B. A., Brody-Karpin, S. D., Zaretsky, E. J., Tang, M., Lopez de Leon, A., Xiang, H., Gusti, V., Clausen, I.G., Olsen, P.B., Rasmussen, M.D., Andersen, J.T., Jorgensen, P.L., Larsen, T.S., Sorokin, A., Bolotin, A., Lpidus, A., Galleron, N., Ehrlich, S.D., Berka, R. M. (2004). Complete genome sequence of the industrial bacterium *Bacillus licheniformis* and comparisons with closely related *Bacillus* species. *Genome Biol* 5(10), R77. <https://doi.org/10.1186/gb-2004-5-10-r77>
- Salkinoja-Salonen, M. S., Vuorio, R., Andersson, M. A., Kampfer, P., Andersson, M. C., Honkanen-Buzalski, T., Scoging, A. C. (1999). Toxigenic strains of *Bacillus licheniformis* related to food poisoning. *Appl Environ Microbiol* 65(10), 4637–4645.

Stackebrandt, E, & Goebel, B.M. (1994). Taxonomic note: a place for DNA-DNA reassociation and 16S rDNA sequence analysis in the present species definition in bacteriology. *Int J Syst Bacteriol* 44, 846–849.

Takami, H., Nakasone, K., Takaki, Y., Maeno, G., Sasaki, R., Masui, N., Fuji, F., HIRAMA, C., Nakamura, Y., Ogasawara, N., Kuhara, S., Horikoshi, K. (2000). Complete genome sequence of the alkaliphilic bacterium *Bacillus halodurans* and genomic sequence comparison with *Bacillus subtilis*. *Nucleic Acids Res* 28(21), 4317–4331.

Turnbull, P. C. (1996). *Medical microbiology* (4th ed.) (S. Baron, Ed.). Galveston, TX: University of Texas Medical Branch at Galveston.

A Restriction Site (*in silico*) Reevaluation of a Chloroplast Gene Phylogeny for a Common Fern Group: Comparisons with Nucleotide Data and Ordination Analyses

William D. Speer

Salt Lake Community College

Abstract

Previous studies have evaluated phylogenetic relationships within the genus Pteridium (bracken fern) using the rps4 gene and the rps4-trnS spacer sequences, either alone or in conjunction with other gene sequences. This study compares sequence data previously submitted to GenBank with restriction site data generated in silico for rps4 and the rps4-trnS spacer. The restriction site data joined the African P. aquilinum subspecies capense and centrali-africanum with the North American and Hawaiian bracken, but not with the European subsp. aquilinum. Because this finding differs from previous phylogenetic

analyses, it was carefully evaluated. Indels were found in the *rps4-trnS* spacer of the outgroup *Paesia scaberula*, some of which corresponded to those previously reported for *P. esculentum*, while another clearly distinguished *Paesia* from all *Pteridium* taxa. Ordination analyses of restriction site data generated for *Paesia* and *Pteridium* specimens were performed using principal components analysis (PCA) and nonmetric multidimensional scaling (NMDS). Three distinct *Pteridium* groupings were obtained in both ordination analyses: 1) *P. esculentum*; 2) *P. aquilinum* subsp. *aquilinum*; and 3) all other *P. aquilinum* subspecies. Additionally, subsp. *pinetorum* formed a distinct subgroup using PCA. To this extent, ordination results were mostly consistent with the phylogenetic results.

Introduction

Pteridium Gled. ex Scopoli, or bracken fern, is a cosmopolitan genus in the Dennstaedtiaceae that is currently recognized as having two diploid ($2n=104$) species: *P. aquilinum* (L.) Kuhn and *P. esculentum* (G. Forst.) Cockayne (Marrs and Watt, 2006). In addition, the molecular work of Thomson and Alonso-Amelot (2002) has identified two allotetraploid ($4n=208$) taxa, *P. caudatum* (L.) Maxon and *P. semihastatum* (N. Wallich ex J. G. Agardh) S. B. Andrews. For almost two decades, infrageneric relationships within the genus have been phylogenetically evaluated using the chloroplast *rps4* gene and the *rps4-trnS* intergenic spacer, either alone or in combination with other gene sequence data. Most of these studies have been limited to evaluating only specific taxa or bracken within certain geographical regions (e.g., Speer, 2000; Thomson et al., 2005; Thomson et al., 2008; Speer, 2008; Zhou et al., 2014; Wolf et al., 2015). On the other hand, Der et al. (2009) produced a global bracken phylogeny, using specimens from around the world (except for *P. aquilinum* subsp. *feeii*).

Expanding on the previous work of Speer et al. (2001), which had identified indels in the *rps4-trnS* spacer that placed bracken taxa into three groups consisting of 1) *P. aquilinum* subspecies *decompositum*, *latiusculum*, *pinetorum* (formerly treated as Eurasian *latiusculum*), *pseudocaudatum*, *pubescens*, and *wightianum* (= *P. revolutum* (Blume) Nakai); 2) *P. aquilinum* subsp. *aquilinum*; and 3) *P. esculentum*, Thomson et al. (2005)¹ designated these groups as indel haplotypes A, B, and C, respectively, and added *P. esculentum* subsp. *arachnoideum* (= *P. arachnoideum*) to haplotype C and subspecies *capense* and *centrali-*

¹ Thomson et al. (2005) cites Speer et al. (2001) as “Speer, Sheffield & Wolf, 2002.”

africanum to haplotype B. The subsequent work of Thomson et al. (2008) identified the Mexican subspecies *feei* as having a haplotype A indel pattern.

Although molecular and morphological studies have clarified many aspects of bracken systematics, particularly at the species level, other issues, mostly infraspecific, remain problematic. Although most recent assessments recognize 11 subspecies in *P. aquilinum* and 2 subspecies in *P. esculentum* (Marrs and Watt, 2006; Thomson, 2012), many of these infraspecific taxa cannot be reliably separated using molecular approaches. For instance, although the eastern North American subspecies *latiusculum* and *pseudocaudatum* are morphologically distinct (Speer and Hilu, 1998), they cannot be distinguished using *rps4* with *rps4-trnS* spacer sequences (Speer, 2008). In other cases, conflicting results have occasionally been obtained. For example, the chloroplast *rps4* study of Speer (2000) indicated that subsp. *pinetorum* (=Eurasian var. *latiusculum* sensu Tryon (1941)) was distinguishable from, but closely related to, the North American subsp. *latiusculum*. On the other hand, arbitrarily primed PCR (AP-PCR) and inter-simple sequence repeat (ISSR) fingerprinting (nuclear genome) implied that subsp. *pinetorum*'s affinities may be closer with subsp. *aquilinum*, a predominantly European taxon (Thomson et al., 2005), than to the North American subsp. *latiusculum*. Although many modern evaluations treat Tryon's (1941) Eurasian var. *latiusculum* as two taxa, subsp. *pinetorum* and subsp. *japonicum* (e.g., Thomson, 2004), the precise relationship between them is unclear. In the previously cited Thomson et al. (2005) study using AP-PCR and ISSR fingerprinting, the affinities of subsp. *japonicum* were clearly with North American bracken, but distinct from subsp. *pinetorum*. On the other hand, Der et al. (2009), using both *rps4* and *rpl16* intron sequence data, found that these two were united in a clade together, although neither formed a monophyletic group by itself. These are just a few of the many possible examples clearly indicating that many aspects of the phylogenetic relationships within this genus remain to be clarified.

This study re-evaluates aspects of *rps4* plus the *rps4-trnS* spacer nucleotide-based phylogenies of *Pteridium* using *in silico* restriction site analyses. Nucleotide and restriction site phylogenies are compared, with similarities and differences being closely scrutinized.

In silico restriction site analyses have been used previously, either alone or in conjunction with other molecular approaches (including actual, or *in vitro*, restriction fragment length polymorphism (RFLP) analysis) for taxon identification and/or as part of phylogenetic analysis. For example, this methodology has been used to evaluate genetic diversity among phytoplasmas that infect *Opuntia* species (Cai et al.,

2008), identification and infraspecific phylogenetic analysis of isolates of the pathogenic fungus *Colletotrichum gloeosporioides* (Ramdeen and Rampersad, 2013), identification of cryptic species in the genus *Mecinus*, or stem mining weevils (Toševski et al., 2013), and the identification and phylogenetic analysis of bovid taxa (Singh et al., 2014).

Materials and Methods

Taxon selection

There were 61 sequences covering the chloroplast *rps4* gene and *rps4-trnS* intergenic spacer in *Pteridium*. Sequences were selected to represent the taxonomic and geographic diversity of the two diploid bracken species, *P. aquilinum* and *P. esculentum*. None of the known tetraploid taxa were included. It should be noted that all specimens sometimes treated as subsp. *japonicum* were included with subsp. *pinetorum* in this study. In addition to the bracken fern sequences, a sequence was included also for *Paesia scaberula* (A.Rich.) Kuhn, another fern species in the Dennstaedtiaceae, which was used as the outgroup taxon. All sequences used in this study were downloaded from GenBank (<https://www.ncbi.nlm.nih.gov/genbank/>). None of the sequences used here were generated specifically for this study. The sequences represent a combination of sequences previously deposited by both the author and those deposited by other researchers. Table 1 lists sequences by taxon and GenBank accession number.

Sequence alignment

Sequences were easily aligned manually. In many cases, the ends of sequences were trimmed to remove ambiguous or missing nucleotide positions and to ensure a more uniform alignment. The length of the alignment, including gaps, was 968 nucleotide positions and covered most of the *rps4* plus *rps4-trnS* spacer region.

In silico restriction site analysis

In silico restriction site analyses were performed on trimmed sequences with gaps removed. These evaluations were performed at the EcMLST website (Qi et al., 2004), operated by the Michigan State University Microbial Evolution Laboratory, using the online tool *In Silico* RFLP (<http://www.shigatox.net/ecmlst/cgi-bin/insilicorflp>). After screening, 12 restriction enzymes were found to be useful: AclI, AluI, ApoI, BfaI, BslI, HaeI, HaeIII, HinfI, HpyCH4III, RsaI, TaqI, and TfiI. For each enzyme, cut sites in each sequence were identified using the

Table 1. Specimens (gene sequences) for each taxon listed by GenBank accession number	
Taxon	GenBank accession numbers
<i>P. aquilinum</i> :	
subsp. <i>aquilinum</i>	AF197096, AF197098, AF197099, DQ426653, DQ426656, DQ486980, DQ486981, DQ486982, FJ177159, FJ177163, FJ177165, FJ177166, FJ177167, FJ177169, FJ177170, FJ177173, FJ177174, FJ177207
subsp. <i>capense</i>	AY626800, FJ177175, FJ177176, FJ177177, FJ177179, FJ177181, FJ177182
subsp. <i>centrali-africanum</i>	AY626802, FJ177183, FJ177184, FJ177185
subsp. <i>decompositum</i>	AF197100, DQ426650, DQ426658
subsp. <i>feei</i>	KT345845
subsp. <i>latiusculum</i>	AF236065, DQ426651, DQ486979
subsp. <i>pinetorum</i>	AF197097, AF197103, AF197104, DQ416775, DQ426654, DQ426659, FJ177154, FJ177155, FJ177156, FJ177157, FJ177188, FJ177195, KC737150, KC737161, KC737163, KC737164
subsp. <i>pseudocaudatum</i>	DQ416774
subsp. <i>pubescens</i>	AF197095, DQ416771
subsp. <i>wightianum</i>	DQ416773, FJ177215
<i>P. esculentum</i>	
subsp. <i>arachnoideum</i>	FJ177138, FJ177140
subsp. <i>esculentum</i>	AF197102, DQ426655
<i>Paesia scaberula</i> (outgroup)	KC813147

In Silico RFLP tool's output and scored as absence/presence data (0/1). The resulting restriction site data matrix had 51 characters.

Phylogenetic analyses

Both nucleotide sequences and restriction site data were evaluated using parsimony with bootstrapping in PAUP* ver. 4.0b10 (Swofford, 1999). For both data sets, the following statistics were obtained for tree analysis: consistency index (CI), the retention index (RI), the rescaled consistency index (RC), the number of equally parsimonious trees, tree

length, and the number of parsimony informative characters. All characters were unordered and of equal weight. For nucleotide sequences, indels in the *rps4-trnS* spacer were coded following Simmons and Ochoterena (2000). Otherwise, gaps were treated as missing data. In the end, there were 971 characters (968 from the initial alignment plus 3 coded indel regions) in the nucleotide analysis.

Pairwise distance matrices were obtained for each data set as follows. All taxa were placed in one of 10 groups according to taxon or geographical region: 1) OG (the outgroup *Paesia scaberula*); 2) Pinet (subsp. *pinetorum*); 3) ENA (Eastern North America (subspecies *latiusculum* & *pseudocaudatum*); 4) Aquil (subsp. *aquilinum*); 5) Capen (subsp. *capense*); 6) CA (subsp. *capense*); 7) Escul (*P. esculentum*); 8) WNH (Western North American & Hawaii (subspecies *pubescens* & *decompositum*); 9) Wight (subsp. *wightianum*); 10) Feei (subsp. *feei*). For the restriction site data, pairwise distances (mean character differences) were initially obtained in PAUP* for individual sequences. Average group pairwise distances were then subsequently manually calculated. On the other hand, group pairwise distances were directly obtained for the nucleotide sequences using MEGA 7.0.14 (Kumar et al., 2016). As the purpose of MEGA is to analyze molecular data, coded indel characters could not be included in this analysis. MEGA allows the user to define taxon groups prior to analysis. Tamura 3-parameter (Tamura, 1992) pairwise distances were determined to be the most appropriate using “Find Best DNA/Protein Model” option (under the “Model” tab) with “Gaps/Missing Data Treatment” set to complete deletion. Reported in this study are the net average group pairwise values obtained for the nucleotide data.

Comparison of the resulting cladogram for the nucleotide with indels coded sequences with that obtained for the restriction site data revealed several significant differences, while both pairwise distance matrices indicated several similarities (see Results). To determine whether the difference between the two phylogenies is simply due to a lower number of informative sites in the restriction site data set, as well to further evaluate phylogenetic relationships, a second phylogenetic analysis on the nucleotide sequences was carried out, but this time with indels treated as missing data and not coded.

Ordination analyses

To further evaluate the restriction site profiles obtained *in silico*, the program PAST 3.10 (Hammer et al., 2001) was used to perform ordination analyses. Because of the generally low level of cut site variation for the taxa include here (see Results), ordinations were per-

formed on the combined data set and not for the individual enzyme results. Principal components analysis (PCA) and nonmetric multidimensional scaling (NMDS) were both performed on the restriction site data set. For the PCA, a variance–covariance matrix was calculated and the percent of variance accounted for by each PCA axis was recorded. A Jaccard similarity index was used for NMDS. Data points were plotted in a three-dimensional coordinate system. For evaluation of the resulting NMDS plot, the stress value (a measure of the fit between ordination and data point distances) and was obtained and recorded.

Results

Alignment of indel regions for outgroup and ingroup taxa

For the previously mentioned *rps4-trnS* spacer indels, the outgroup taxon *Paesia scaberula* exhibited a pattern basically identical to that for *P. esculentum*, which was very different from either pattern observed for the *P. aquilinum* sequences (Figure 1). Additionally, another indel region was observed in the alignment that distinguished *Paesia* from all *Pteridium* specimens (Figure 2).

<i>Paesia scaberula</i>	CTTC----AGTTCGGACGGCTTCATTCAAAAATCATGTCTAGTC
<i>Pteridium esculentum</i> :	Haplotype C
subsp. <i>esculentum</i>	TTTT----GGTTGGACGGCTTAAATTGAAACCCAAGTCTAGTC
subsp. <i>arachnoideum</i>	TTTT----GGTTGGACGGCTTAAATTGAAACCCAAGTCTAGTC
<i>Pteridium aquilinum</i> :	Haplotype A
subsp. <i>decompositum</i>	TTTT----GGTTGGACGGCTTAAATTGAAACCCA----AGTC
subsp. <i>latiusculum</i>	TTTT----GGTTGGACGGCTTAAATTGAAACCCA----AGTC
subsp. <i>pinetorum</i>	TTTT----GGTTGGACGGCTTAAATTGAAACCCA----AGTC
subsp. <i>pseudocaudatum</i>	TTTT----GGTTGGACGGCTTAAATTGAAACCCA----AGTC
subsp. <i>pubescens</i>	TTTT----GGTTGGACGGCTTAAATTGAAACCCA----AGTC
subsp. <i>wightianum</i>	TTTT----GGTTGGACGGCTTAAATTGAAACCCA----AGTC
subsp. <i>feei</i>	TTTT----GGTTGGACGGCTTAAATTGAAACCCA----AGTC
	Haplotype B
subsp. <i>aquilinum</i>	TTTTGTTTTGGTTGGACGGCTTAAATTGAAACCCA----AGTC
subsp. <i>capense</i>	TTTTGTTTTGGTTGGACGGCTTAAATTGAAACCCA----AGTC
subsp. <i>centrali-africanum</i>	TTTTGTTTTGGTTGGACGGCTTAAATTGAAACCCA----AGTC

Figure 1. Alignment of taxa with respect to a previously identified indels in the chloroplast *rps4-trnS* spacer of *Pteridium*. Shown nucleotide alignment corresponds (complementarily) with positions 43707–43746 of the *P. aquilinum* complete chloroplast genome (GenBank HM535629).

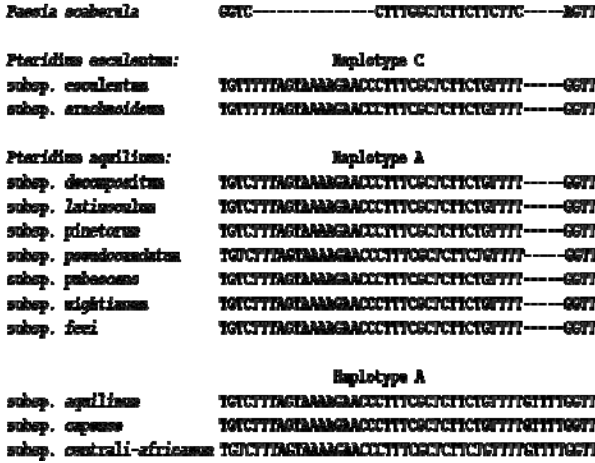


Figure 2. Alignment of taxa with respect to a previously unidentified indel in the chloroplast *rps4-trnS* spacer that distinguishes *Paesia* from *Pteridium*. This alignment partially overlaps with the alignment shown in Figure 1. This alignment corresponds (complementarily) with positions 43734-43779 of the *P. aquilinum* complete chloroplast genome (GenBank HM535629).

In silico restriction site analysis

For the 12 enzymes used in this study, a total of 51 cut sites were scored (Table 2). Of these, 36 (70.6%) were in the *rps4* gene itself and

Table 2. Number of scored cut sites obtained <i>in silico</i> by restriction enzyme	
Enzyme	No. of cut sites scored
Acil	4
AluI	3
ApoI	4
BfaI	7
BsII	2
HaeI	2
HaeIII	3
Hinfl	8
HpyCH4III	4
RsaI	3
TaqI	6
TfiI	5
Total	51

15 (29.4%) were in the *rps4-trnS* spacer. Several enzymes produced profiles that distinguished *Paesia* from all *Pteridium* specimens. In some of these cases, *P. aquilinum* and *P. esculentum* were also distinguished from each other. Additionally, distinct restriction site profiles were obtained for some of the *P. aquilinum* subspecies: subsp. *aquilinum* (HaeIII and TaqI), subsp. *centrali-africanum* (ApoI), subsp. *pinetorum* (AluI), and subsp. *wightianum* (RsaI). Table 3 provides more complete information as to which taxa were distinguished by the 12 restriction enzymes used in this study.

Table 3. Taxa distinguished by the 12 restriction enzymes	
Enzyme	Taxa distinguished
AcI	<i>Paesia</i> , <i>P. aquilinum</i> , <i>P. esculentum</i>
AluI	<i>Paesia</i> , *subsp. <i>pinetorum</i> , all other taxa
ApoI	<i>Paesia</i> , *subsp. <i>centrali-africanum</i> , <i>P. esculentum</i> (except Brazil), all other taxa
BfaI	<i>Paesia</i> , <i>P. aquilinum</i> , <i>P. esculentum</i>
BsII	<i>Paesia</i> (no cut sites), all <i>Pteridium</i>
HaeI	<i>Paesia</i> , all <i>Pteridium</i>
HaeIII	*subsp. <i>aquilinum</i> & <i>P. esculentum</i> , all other taxa
HinfI	<i>Paesia</i> , <i>P. aquilinum</i> , <i>P. esculentum</i>
HpyCH4III	<i>Paesia</i> , all <i>Pteridium</i>
RsaI	<i>Paesia</i> , *subsp. <i>wightianum</i> (& 1 *subsp. <i>pinetorum</i>), all other taxa
TaqI	*subsp. <i>aquilinum</i> , all other taxa
TfiI	<i>Paesia</i> , <i>P. aquilinum</i> , <i>P. esculentum</i>

Phylogenetic analysis-nucleotide sequences with indels coded

The results of the nucleotide with indels coded parsimony analysis were congruous with previous phylogenetic analyses (see Introduction) and distinguished bracken taxa basically along the lines of indel haplotype (Figure 3). The parsimony analysis generated six equally parsimonious trees of length 119. Tree support values were CI=0.983, RI=0.987, and RC=0.970; indicating that the resulting trees are all well supported by the data. Finally, there were 23 parsimony informative characters. Bootstrap support was very robust for both *P. aquilinum* (98%) and *P. esculentum* (100%). Within *P. aquilinum*, several smaller subclades appeared. The most noticeable of these corresponded to indel haplotype B (subspecies *aquilinum*, *capense*, and *centrali-africanum*).

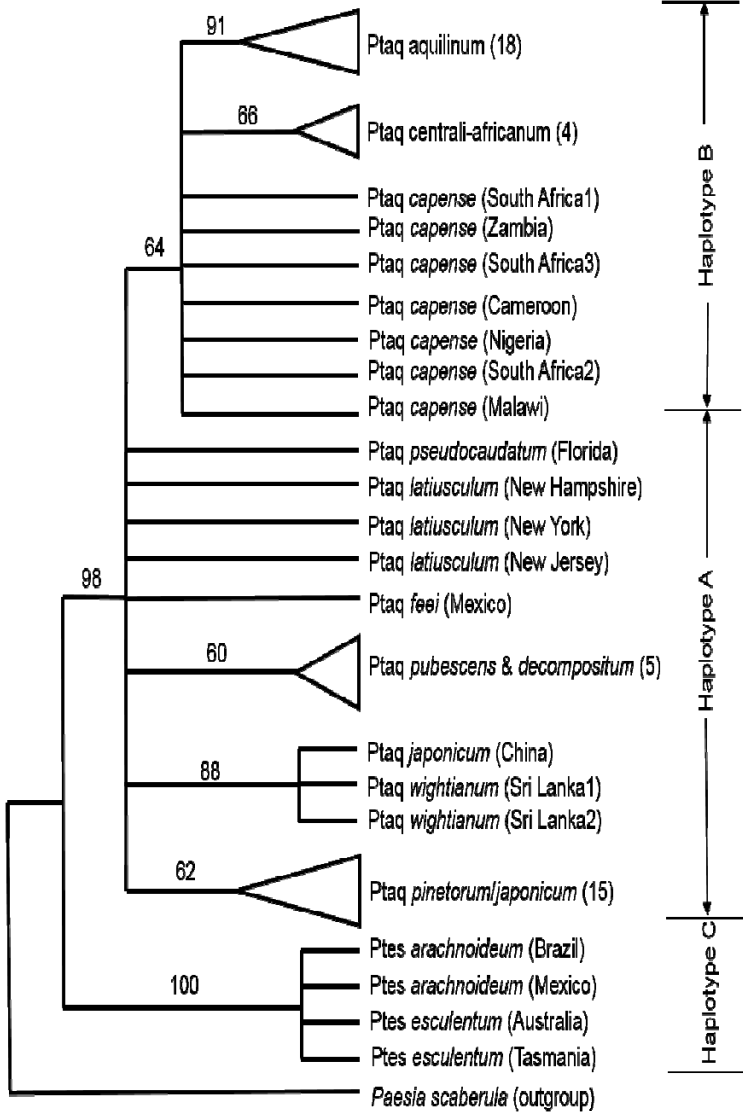


Figure 3. Phylogenetic tree for chloroplast *rps4* and *rps4-trnS* spacer nucleotide sequence data. Indels in the *rps4-trnS* spacer were coded. Correspondence of taxa with previously identified indel haplotypes (see Introduction) is indicated. Numbers above lines are bootstrap support values. Ptaq=subspecies of *P. aquilinum*; Ptes=subspecies of *P. esculentum*.

Within this, subsp. *aquilinum* had a strong bootstrap support of 91%, whereas subsp. *centrali-africanum* was weakly supported at 66%. Also within *P. aquilinum*, all specimens of subsp. *pinetorum* (includes most *japonicum* specimens) formed a distinct subclade (62%), as did the Western North American subsp. *pubescens* and the Hawaiian subsp. *decompositum* (60%). The East Asian subsp. *wightianum* and one rogue *japonicum* specimen formed a moderately well supported subclade (88%).

Phylogenetic analysis-restriction sites

Phylogenetic analysis of the restriction site data resulted in a single tree of length 34. This tree was moderately to well supported by the data with $CI=0.882$, $RI=0.952$, and $RC=0.840$. There were 13 parsimony informative characters. The resulting phylogenetic tree for the restriction site data (Figure 4) differed on several points from that generated for the nucleotide sequences. The most obvious difference was that, whereas indel haplotype B (subspecies *aquilinum*, *capense*, and *centrali-africanum*) formed a distinct subclade for the nucleotide with indels coded, this did not occur for the restriction site data. Also, the *pubescens/decompositum* subclade of the previous phylogeny was absent in this analysis. Finally, *P. esculentum* was not as well resolved. In part, this was because the Brazilian subsp. *arachnoideum* specimen had a restriction site profile that differed slightly from the other members of this species for ApoI and TaqI. On the other hand, *P. aquilinum* was well supported with a 92% bootstrap value. As with the nucleotide analysis, subclades were formed, respectively, for subspecies *aquilinum*, *centrali-africanum*, *pinetorum*, and *wightianum*, although these were weakly supported.

Phylogenetic analysis-nucleotide sequences without indels coded

The second nucleotide analysis (without indels coded) produced a bootstrap consensus tree whose topology was noticeably different from the first (with indels coded), and that resembled, in many respects, the cladogram obtained for the restriction site phylogeny. This is shown in Figure 5. The most conspicuous similarity was that it also did not group the haplotype B taxa into a single clade. In contrast to the restriction site results, however, *P. esculentum* was better resolved and subspecies *pubescens* and *decompositum* formed a subclade. This analysis resulted in 24 equally parsimonious trees of length 116. Tree support values

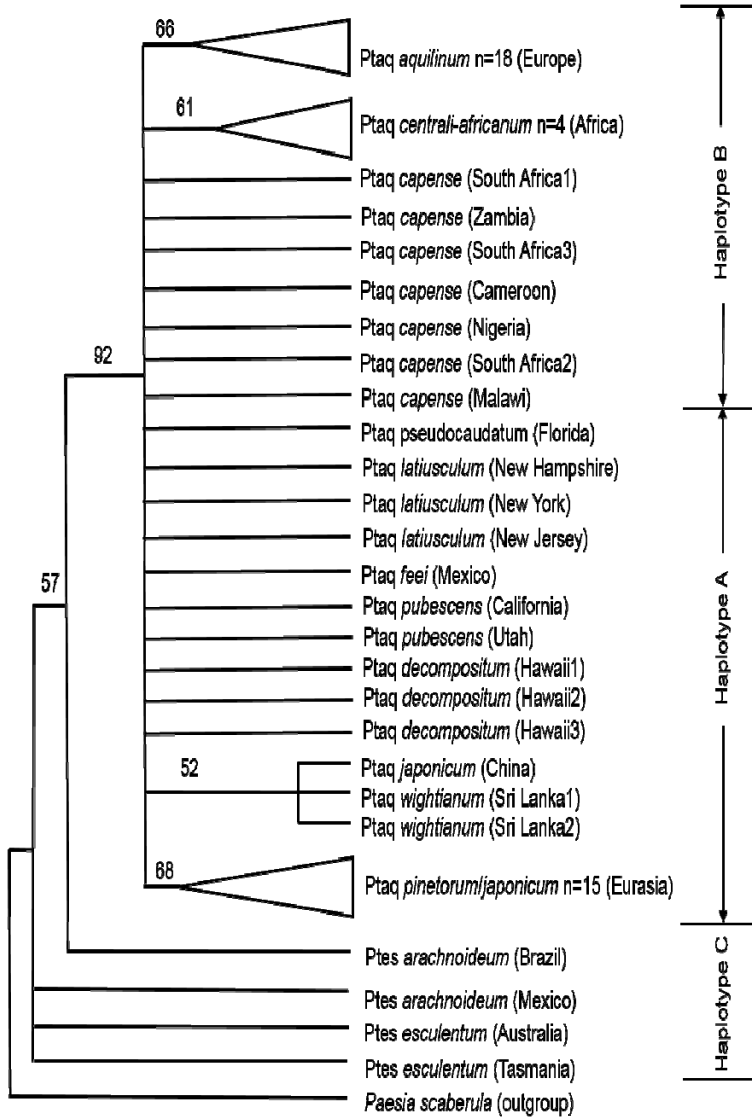


Figure 4. Phylogenetic tree for chloroplast *rps4* and *rps4-trnS* spacer using *in silico* generated restriction site data. Although coded indels were not included in this analysis, correspondence of taxa with previously identified indel haplotypes is indicated. Numbers above lines are bootstrap support values. Ptaq=subspecies of *P. aquilinum*; Ptes=subspecies of *P. esculentum*.

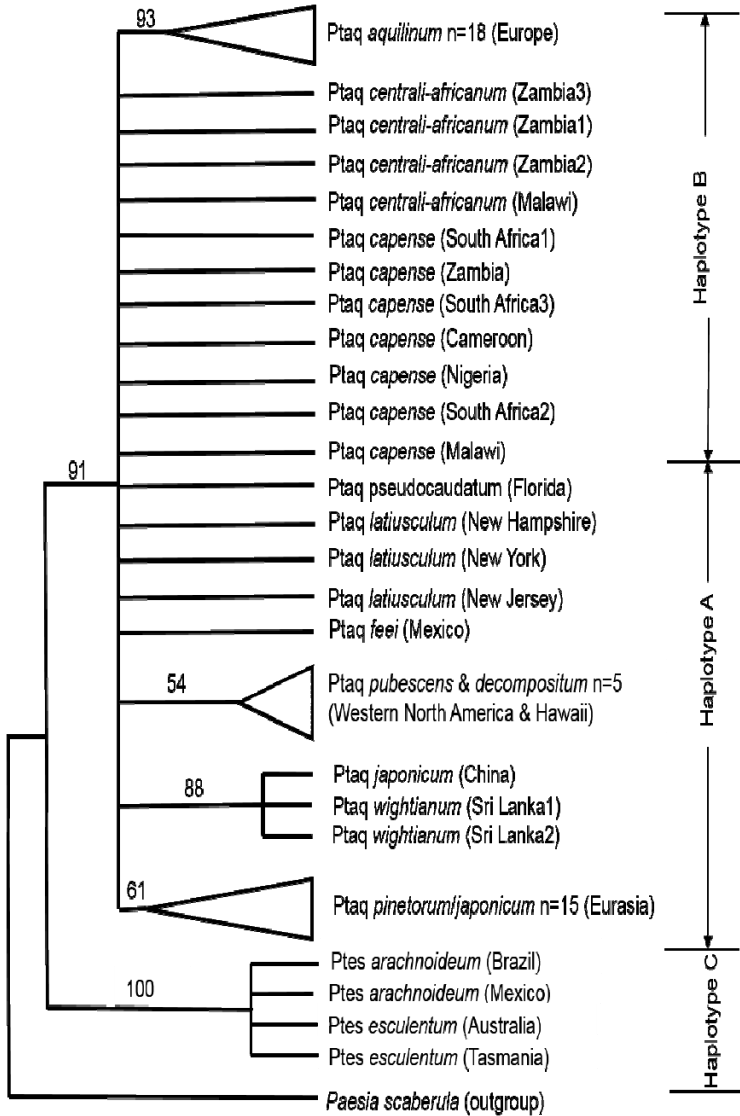


Figure 5. Phylogenetic tree for chloroplast *rps4* and *rps4-trnS* spacer nucleotide sequence data. Indels in the *rps4-trnS* spacer were not coded. Though coded indels were not included in this analysis, correspondence of taxa with previously identified indel haplotypes is indicated. Numbers above lines are boot-strap support values. Ptaq=subspecies of *P. aquilinum*; Ptes=subspecies of *P. esculentum*.

were $CI=0.983$, $RI=0.984$, and $RC=0.967$; again indicating that the resulting trees are all well supported by the data. There were 21 parsimony informative characters.

Pairwise distances

Both sets of pairwise distance indicated low levels of divergence among bracken taxa. This was particularly the case for the nucleotide data set, where the pairwise Tamura 3-parameter distances were consistently <0.02 , even between the two *Pteridium* species. In both distance matrices, the greatest values obtained were between the two genera. The Mexican subsp. *feei* was indistinguishable from the Eastern North American subspecies in both distance matrices, although it should be recalled that only a single *feei* sequence was downloaded for this study. Within *P. aquilinum*, subsp. *aquilinum* appeared to be the most consistently divergent taxon using either distance measure. Pairwise distances (mean character differences) for the restriction site data (Table 4) indicated that the African subsp. *capense* could not be distinguished from any of the subspecies found in North America (subspecies *latiusculum*, *pseudocaudatum*, *pubescens*, and *feei*) and Hawaii (subsp. *decompositum*), despite having a different indel haplotype. Along with subsp. *centrali-africanum*, the restriction site data suggested that the affinities of the African taxa may be more with the taxa in North America and Hawaii and less with the mostly European subsp. *aquilinum*. A similar trend was also observed for the pairwise distances for the nucleotide data (Table 5).

Ordination analyses

The PCA and NMDS analyses of the generated combined restriction site profiles were in general agreement. *P. esculentum* and *P. aquilinum* were strongly separated and clearly distinguishable. In both ordinations, and consistent with the phylogenetic analyses, subsp. *aquilinum* formed a distinct grouping within *P. aquilinum*. Additionally, the African subspecies *capense* and *centrali-africanum*, as well as the East Asia subsp. *wightianum*, are unequivocally associated with the North American (subspecies *feei*, *latiusculum*, *pseudocaudatum*, and *pubescens*) and Hawaiian (subsp. *decompositum*) taxa and not with the predominantly European subsp. *aquilinum*. This is not consistent with the indels coded phylogenetic analysis but is otherwise consistent with the other two generated phylogenies. In the PCA plot, the remaining subspecies of *P. aquilinum* were further segregated into two groups consisting of 1) subspecies *pinetorum* and 2) the other remaining subspecies (Figure 6). Again, the appearance of a distinct *pinetorum*

	1	2	3	4	5	6	7	8	9	10
OG	0.000									
Pinet	0.487	0.000								
ENA	0.471	0.023	0.000							
Aquil	0.507	0.062	0.039	0.000						
Capen	0.471	0.023	0.000	0.040	0.000					
CA	0.490	0.043	0.020	0.059	0.020	0.000				
Escul	0.382	0.161	0.137	0.137	0.137	0.157	0.000			
WNH	0.471	0.023	0.000	0.039	0.000	0.020	0.137	0.000		
Wight	0.451	0.040	0.020	0.059	0.020	0.039	0.157	0.020	0.000	
Feei	0.471	0.023	0.000	0.039	0.000	0.020	0.137	0.000	0.020	0.000

OG=outgroup, Pinet=subsp. *pinetorum*, ENA=Eastern North America (subspecies *latusculum* & *pseudocaudatum*), Aquil=subsp. *aquilinum*, Capen=subsp. *capense*, CA=subsp. *capense*, Escul=*P. esculentum*, WNH=Western North American & Hawaii (subspecies *pubescens* & *decompositum*), Wight=subsp. *wightianum*, Feei=subsp. *feei*.

	1	2	3	4	5	6	7	8	9	10
OG	0.000									
Pinet	0.095	0.000								
ENA	0.093	0.001	0.000							
Aquil	0.097	0.004	0.003	0.000						
Capen	0.093	0.001	0.000	0.003	0.000					
CA	0.092	0.002	0.001	0.004	0.001	0.000				
Escul	0.091	0.014	0.013	0.014	0.013	0.014	0.000			
WNH	0.095	0.002	0.001	0.004	0.001	0.002	0.014	0.000		
Wight	0.096	0.003	0.002	0.005	0.002	0.003	0.015	0.003	0.000	
Feei	0.093	0.001	0.000	0.003	0.000	0.001	0.013	0.001	0.002	0.000

OG=outgroup, Pinet=subsp. *pinetorum*, ENA=Eastern North America (subspecies *latusculum* & *pseudocaudatum*), Aquil=subsp. *aquilinum*, Capen=subsp. *capense*, CA=subsp. *capense*, Escul=*P. esculentum*, WNH=Western North American & Hawaii (subspecies *pubescens* & *decompositum*), Wight=subsp. *wightianum*, Feei=subsp. *feei*.

group is congruent with all phylogenetic analyses presented here. It should be noted, however, that this was not observed in the NMDS plot (Figure 7). PCA axes 1 and 2 accounted for 35.72% and 30.16%, respectively, of the observed variance, for a combined total of 65.88%. The NMDS plot had a stress value of 0.1341, or 13.41%, which, although not stellar, indicates that the ordination is acceptably representative of the values in the distance matrix.

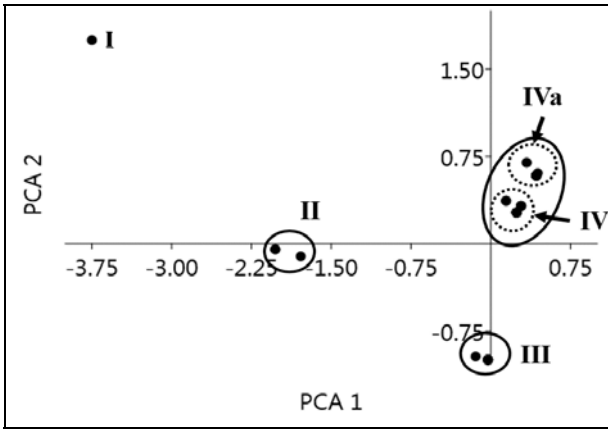


Figure 6. Principal components analysis (PCA) of *in silico* generated restriction site data for 62 specimens. In many cases, specimens shared the same combined restriction site profile and occupy the same position in the ordination scatterplot. **I**=*Paesia scaberula*; **II**= *Pteridium esculentum*; **III**=*P. aquilinum* subsp. *aquilinum*; **IVa**=*P. aquilinum* subsp. *pinetorum*; **IVb**=*P. aquilinum* subspecies *capense*, *centrali-africanum*, *decompositum*, *feei*, *latiusculum*, *pseudocaudatum*, *pubescens*, and *wightianum*.

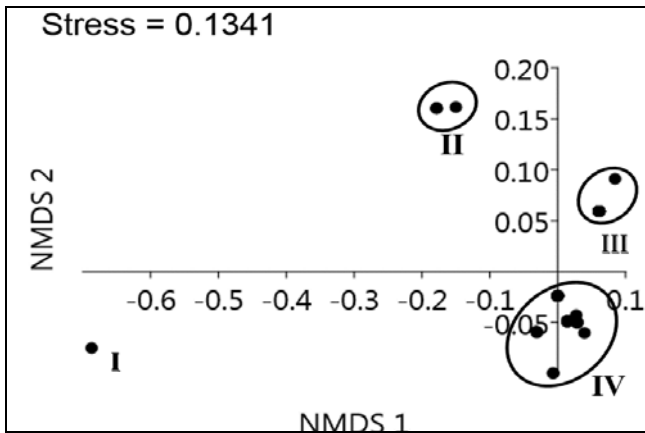


Figure 7. Non-metric multidimensional scaling (NMDS) plot for *in silico* generated restriction site data for 62 specimens. In many cases, specimens shared the same combined restriction site profile and occupy the same position in the ordination scatterplot. **I**=*Paesia scaberula*; **II**= *Pteridium esculentum*; **III**=*P. aquilinum* subsp. *aquilinum*; **IV**=all other *P. aquilinum* subspecies (*capense*, *centrali-africanum*, *decompositum*, *feei*, *latiusculum*, *pinetorum*, *pseudocaudatum*, *pubescens*, and *wightianum*).

Discussion

Although not identical, the restriction site and the nucleotide without indels coded phylogenies are construed here as being in broad general agreement with each other in terms of their respective phylogenetic results for *P. aquilinum*. Both approaches shared phylogenetic similarities that clearly distinguish them from the nucleotide with indels coded phylogeny. Thomson et al. (2005) discovered that the African subspecies *capense* and *centrali-africanum* had an indel pattern identical to that of the basically European subsp. *aquilinum* (indel haplotype B) in the *rps4-trnS* spacer. However, the restriction site and the nucleotide without indels coded results presented here suggest that, indel haplotypes aside, the evolutionary affinities of these African bracken are closer to the North American and Hawaiian taxa and less so with the European plants than previously understood. This point is important as inclusion of the coded indels, although also a relevant consideration, did tend to mask the close chloroplast nucleotide similarities of the African group with North American and Hawaiian *Pteridium*.

One of the long-standing problems in *Pteridium* systematics is the high degree of genetic similarity among morphologically distinct bracken taxa, making it frequently difficult to consistently distinguish between these taxa on a molecular basis. Even between the bracken species *P. esculentum* and *P. aquilinum*, the amount of nucleotide divergence tends to be low, as is indicated in this study for *rps4* plus *rps4-trnS* spacer sequences. This has been observed for other types of nucleotide data as well. For example, the chloroplast *atpB* study of Wolf (1997) distinguished between *P. aquilinum* and *P. esculentum*. However, Speer (2000) found that *atpB* sequences appeared to be of little value in elucidating infraspecific relationships within *P. aquilinum*. Even in the global bracken fern study of Der et al. (2009), which used *rpl16* intron sequences in combination with *rps4* plus *rps4-trnS* spacer data, relationships between many infraspecific appeared to be resolved, while others were not.

With the exception of subspecies *capense* and *centrali-africanum*, both PCA and NMDS tended to group the bracken taxa in a fashion that roughly corresponded to indel haplotypes A, B, and C. In this study, both ordination analyses of the combined restriction site data consistently distinguished *P. esculentum* from *P. aquilinum* as a whole, as well as reliably distinguishing subsp. *aquilinum*. Among other things, this indicates the distinctiveness of this particular subspecies within *P. aquilinum*. Additionally, PCA separated out subsp. *pinetorum*, which here includes specimens sometimes treated as subsp. *japonicum*. The only exception here with regard to subsp. *pinetorum*, was a single Chi-

nese *japonicum* specimen that grouped with the *wightianum* material in the ordination and phylogenetic analyses. As these two subspecies do overlap in their distributions (Tryon, 1941), it is possible that this specimen actually belongs to *wightianum*, but was misidentified as a *japonicum* (or *pinetorum*). Tryon (1941) discusses the difficulties of morphological identification of infraspecific bracken taxa whose distributions overlap. Alternatively, it is also possible that this specimen is an infraspecific hybrid with a *japonicum* morphology and a *wightianum* chloroplast genome.

Within *P. aquilinum*, indel haplotype A is most widespread and is found in subspecies *feei* (Mexico), *decompositum* (Hawaii), *latiusculum* (eastern North America), *pinetorum* (Eurasia), *pseudocaudatum* (eastern North America), *pubescens* (western North America), and *wightianum* (predominately East Asia), whereas haplotype B is limited to mainly Europe and Africa. Der et al. (2009) hypothesized that the haplotype C of *P. esculentum* is the ancestral haplotype in the genus, and was followed, in *P. aquilinum*, by haplotype A and, subsequently, haplotype B. The alignment of *Paesia scaberula* with the *Pteridium* specimens presented here (Figure 1) would be consistent with that conjecture, as the *Paesia* sequence had a basic haplotype C pattern at this place in the *rps4-trnS* spacer. An additional indel region was observed also that differentiated between *Paesia* and *Pteridium*. On the basis of the *rps4* plus *rps4-trnS* spacer sequences examined in this study, including the restriction site data, subspecies *capense* and *centrali-africanum* appear to be intermediate between subsp. *aquilinum*, on one hand, and the rest of *P. aquilinum*, on the other. Although the African taxa do have indel haplotype B, like subsp. *aquilinum*, they are otherwise much more similar genetically to the specimens from North America and Hawaii, as clearly indicated by both pairwise distance matrices. In terms of the chloroplast genome of *P. aquilinum*, there is at least one possible explanation for this, considering that indel haplotype B most likely arose in this genus after the appearance of haplotype A (Der et al., 2009) but that the chloroplast nucleotide evidence otherwise indicates a strong systematic relationship between African and North American brackens. If it is allowable to extend these observations to at least the entire the *rps4* plus *rps4-trnS* spacer sequence, and not just the indels themselves, then it may be likely that the North America brackens are representative of an earlier chloroplast genome from which the one found in subsp. *aquilinum* arose later. Although Der et al. (2009) did not expressly make this particular statement about the North American bracken, they did nevertheless point out that subsp. *aquilinum* formed a monophyletic group in their study that arose from a “paraphyletic grade” of subsp. *capense*, as did also subsp. *centrali-*

africanum, as haplotype B expanded from Africa into Europe. The African brackens, based on this chloroplast DNA evidence, appear to occupy a phylogenetic position somewhat intermediate to the North American brackens on one hand and the mainly European subsp. *aquilinum* on the other. Considering the comparative nucleotide and restriction site distinctiveness of subsp. *aquilinum* from other *P. aquilinum* subspecies, and what has been observed with regard to subsp. *capense* and subsp. *centrali-africanum*, this possibility cannot yet be completely ruled out.

Although they have been used often together, there have not been any studies comparing the respective phylogenetic contributions of the *rps4* gene sequences, on one hand, and the *rps4-trnS* spacer, on the other, to the best of this author's knowledge. Since these are actually two distinct nucleotide regions (protein coding vs. noncoding), it is entirely possible that they are evolving at different rates (as is widely known for other such gene sequence comparisons) and may provide different, although not necessarily inconsistent, phylogenetic contributions. It may be useful to analyze these two regions separately in future studies.

An *in silico* approach was taken with respect to the restriction site data, which did provide a context in which to evaluate previously obtained nucleotide phylogenetic results. This ultimately permitted the discovery of relationships between *Pteridium* taxa that were not previously observed.

References

- Cai, H., Wei, W., Davis, R. E., Chen, H., and Zhou, Y. 2008. Genetic diversity among phytoplasmas infecting *Opuntia* species: virtual RFLP analysis identifies new subgroups in the peanut witches'-broom phytoplasma group. *Int. J. Syst. Evol. Microbiol.* 58: 1448-1457.
- Der, J.P., Thomson, J.A., Stratford, J.K., and Wolf, P.G. 2009. Global chloroplast phylogeny and biogeography of bracken (*Pteridium*: Dennstaedtiaceae). *Am. J. Bot.* 96: 1041-1049.
- Hammer, Ø., Harper, D.A.T., Ryan, P.D. 2001. PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica* 4(1): 9pp.

Kumar, S., Stecher, G., and Tamura, K. 2016. MEGA7: Molecular Evolutionary Genetics Analysis Version 7.0 for bigger datasets. *Mol. Biol. Evol.* 33:1870-1874.

Marrs, R. H., and Watt, A. S. 2006. Biological flora of the British Isles: *Pteridium aquilinum* (L.) Kuhn. *J. Ecol.* 94: 1272-1321.

Qi, W., Lacher, D.W., Bumbaugh, A.C., Hyma, K.E., Ouellette, L.M., Large, T.M., Tarr, C.L., and Whittam, T.S. 2004. EcMLST: an online database for multi locus sequence typing of pathogenic *Escherichia coli*. 3rd International IEEE Computer Society Computational Systems Bioinformatics Conference (CSB 2004), August 16-19 2004, Stanford, CA. doi: 10.1109/CSB.2004.1332482

Ramdeen, S., and Rampersad, S.N. 2013. Intraspecific differentiation of *Colletotrichum gloeosporioides* sensu lato based on in silico multilocus PCR-RFLP fingerprinting. *Mol. Biotechnol.* 53: 170–181.

Simmons, M.P., and Ochoterena, H. 2000. Gaps as characters in sequence-based phylogenetic analyses. *Syst. Biol.* 49:369-381.

Singh, U., Dubey, P.P., Sharan, N., Mishra, V.K., Joshi, B.K., and Kumar, D. 2014. *In silico* analysis of mitochondrial-ND-2 gene as species signature and development of PCR-RFLP test for identification of six livestock species. *Int. J. Comput. Bioinformatics In Silico Model.* 3: 440-446.

Speer, W.D. 2000. A systematic assessment of British and North American *Pteridium* using cpDNA gene sequences. In J. A. Taylor and R. T. Smith, eds. *Bracken Fern: Toxicity, Biology and Control*, pp. 37-42. International Bracken Group, Aberystwyth, Wales.

Speer, W.D. 2008. Phylogenetic and biogeographic relationships among North American and Hawaiian *Pteridium aquilinum* (L.) Kuhn (Dennstaedtiaceae) based on chloroplast *rps4* and *rps4-trnS* intergenic spacer sequences. *Am. Fern J.* 98: 179-193.

Speer, W.D and Hilu, K.W. 1998. Relationships between two infraspecific taxa of *Pteridium aquilinum* (Dennstaedtiaceae). I. Morphological evidence. *Syst. Bot.* 23: 305-312.

Speer, W.D., Sheffield, E., and Wolf, P.G. 2001. Relationships among Northern Hemisphere *Pteridium*: some new perspectives. In *Botany 2001: Plants and People*; August 12-16, 2001; Albuquerque, NM. Abstract 349.

Swofford, D.L. 1999. PAUP*. Phylogenetic Analysis Using Parsimony (*and Other Methods). Ver. 4. Sinauer Associates, Sunderland, MA.

Tamura, K. 1992. Estimation of the number of nucleotide substitutions when there are strong transition-transversion and G+C-content biases. *Mol. Biol. Evol.* 9:678-687.

Thomson, J.A. 2004. Towards a taxonomic revision of *Pteridium* (Dennstaedtiaceae). *Telopea* 10: 793-803.

Thomson, J.A. 2012. Taxonomic status of diploid Southern Hemisphere brackens (*Pteridium*: Dennstaedtiaceae). *Telopea* 14: 43-48.

Thomson, J.A. and Alonso-Amelot, M.E. 2002. Clarification of the taxonomic status and relationships of *Pteridium caudatum* (Dennstaedtiaceae) in Central and South America. *Bot. J. Linn. Soc.* 140: 237-248.

Thomson, J.A., Chikuni, A.C., and McMaster, C.S. 2005. The taxonomic status and relationships of bracken ferns (*Pteridium*: Dennstaedtiaceae) from sub-Saharan Africa. *Bot. J. Linn. Soc.* 148: 311-321.

Thomson, J.A., Mickel, J.T., and Mehltreter, K. 2008. Taxonomic status and relationships of bracken ferns (*Pteridium*: Dennstaedtiaceae) of Laurasian affinity in Central and North America. *Bot. J. Linn. Soc.* 157: 1-17.

Toševski, I., Jović, J., Krstić, O., and Gassmann, A. 2013. PCR-RFLP-based method for reliable discrimination of cryptic species within *Mecinus janthinus* species complex (Meciniini, Curculionidae) introduced in North America for biological control of invasive toadflaxes. *BioControl* 58: 563-573.

Tryon, R.M. 1941. A revision of the genus *Pteridium*. *Rhodora* 43: 1-31, 37-67.

Wolf, P.G., 1997. Evaluation of *atpB* nucleotide sequences for phylogenetic studies of ferns and other pteridophytes. *Am. J. Bot.* 84:1429-1440.

Wolf, P.G., Rowe, C.A., Der, J.P., Schilling, M.P., Visger, C.J., and Thomson, J.A. 2015. Origins and diversity of a cosmopolitan fern genus on an island archipelago. *AoB PLANTS* 7: plv118; doi:10.1093/aobpla/plv118.

Zhou, S., Dong, W., Chen, X., Zhang, X., Wen, J., and Schneider, H. 2014. How many species of bracken (*Pteridium*) are there? Assessing the Chinese brackens using molecular evidence. *Taxon* 63: 509-521.

Utah County Housing Trends from 2000-2016: A Quantitative Research Analysis

**James C. Brau, Jeremy R. Endicott, Barrett A. Slade,
and David N. Wilson**

Brigham Young University

Abstract

We examine the Utah County housing market using a sample of over 70,000 single-family residential transactions from 2000 through 2016. To measure the strength of the Utah County residential market, we examine selling price, transaction volume, and number of days the house is on the market. We compare housing prices using two models: a naïve model that calculates the average transaction price over a period, and a hedonic pricing model that gives a detailed, holistic view of how homes are priced. The latter incorporates characteristics of homes not priced in the naïve model. Characteristics include total square feet above and below ground, age of house in years, garage space, total lot area, and other priced factors. When using a hedonic pricing model, we find evidence that home values have experienced a 2.5% annual appreciation from 2000 through 2016. Our study shows that single-family dwellings have increased in line with historical rates over our sample period and not at a real estate bubble pace.

1. Introduction

Anecdotal evidence suggests that housing prices in Utah County and nationwide are increasing. One *Wall Street Journal* author wrote that “home prices are overheating” because of strong demand from buyers and a “dearth of new construction” (Kusisto, Apr. 26, 2017). In another article, Kusisto states, “home-price growth continued to accelerate...a sign that the market is still heating up five years after it hit bottom” (Kusisto, Apr. 25, 2017) Are these statements accurate? This research investigates this primary question. Specifically, the purpose of our study is to empirically investigate recent trends in the Utah County housing market by examining single-family transactions that occurred between the years 2000 and 2016. First, we present naïve measures of the real estate market. Second, we construct a hedonic pricing model to control for quality characteristics of homes (Gatzlaff and Ling, 1994). Third, we compare the naïve and hedonic measures and discuss their disparities.

2. Data Description and Naïve Measures of the Utah County Housing Market

Data Description

The data for this study were obtained from the Wasatch Front Regional Multiple Listing Service. We begin with all transactions during the sample period (e.g., single-family residential, multifamily residential, and commercial properties) for Utah County. To construct a representative, homogeneous sample of house price effects, we eliminate all observations except for detached single-family dwellings. Next, we eliminate extreme house prices (transaction prices below \$80,000 and above \$550,000), following Brau and Slade (2001). The extreme observations have residuals that violate the classical regression assumption of independent and identically distributed error terms. We also eliminated transactions with apparent inaccuracies (e.g., homes reporting zero square feet). After our filters, the residual plot indicates adherence to the underlying model assumptions.

Next, we eliminate observations that have a change between the sales price and the listing price that is greater than three standard deviations from the sales price. We do this because some data received from the listing service contained observations that appeared to be in error. For example, one property is reported to have sold at 10% of the listing price, where as another is reported to have sold at over 300% of the listing price. Such observations are suspect and probably result from

input errors. After we impose our screening process, our sample size is 70,462 transactions from the years 2000 to 2016

We report the summary statistics of the sample in Table 1. An average home in our sample has 2,718 square feet (1,712 above ground and 1,007 in the basement). The mean (median) house has 45% (30%) of the basement finished, 4.0 (4.0) bedrooms, and 2.6 (3.0) bathrooms. The mean (median) home was built in 1989 (1999) and is 20.0 (10.0) years old at the time of the sale. Houses have a mean (median) garage/carport capacity of 1.8 (2.0). The mean (median) listing price is \$232,179 (\$214,500) and the mean (median) transaction price is \$229,669 (\$210,000). This results in an average price per total square foot of \$87.60.

Table 1. Summary Statistics for 70,462 Utah County Housing Transactions, 2000-2016					
Variable	Mean	Median	St. Dev.	Min.	Max.
Total sq. ft.	2,718	2,555	1,048	802	20,300
Sq. ft. above ground	1,712	1,586	634	801	18,500
Sq. ft. basement	1,007	1,056	662	0	8,871
% basement finished	45	30	46	0	100
Total no. beds	4.0	4.0	1.1	1.0	15.0
Total no. baths	2.6	3.0	0.9	1.0	14.0
Year built	1989	1999	24.7	1860	2016
Age of property when sold (yrs)	20.0	10.0	24.4	0.0	155.0
Capacity of the garage/carport (# vehicles)	1.8	2.0	1.0	0.0	15.0
No. of acres	0.31	0.21	0.79	0.01	62.00
List price (\$)	232,179	214,500	92,927	70,000	649,000
Sales price (\$)	229,669	210,000	90,801	80,101	549,982
Price/sq. ft. (\$)	87.6	84.8	24.0	10.0	545.0

Naive Measures at the City Level

Figure 1 lists 21 of the cities included in our study and charts them by the average selling price per house for the years 2014–2016.

The city of Highland ranks as the most expensive, with an average transaction price of \$403,918. Alpine (\$390,071), Woodland Hills (381,883), and Vineyard (\$353,637) are the other cities with average sales prices greater than \$350,000. On the low end, Goshen has the smallest average house price at \$172,329. From the naive plotting of average house prices, it appears from Figure 1 that 16 cities may sell at a premium relative to Provo.

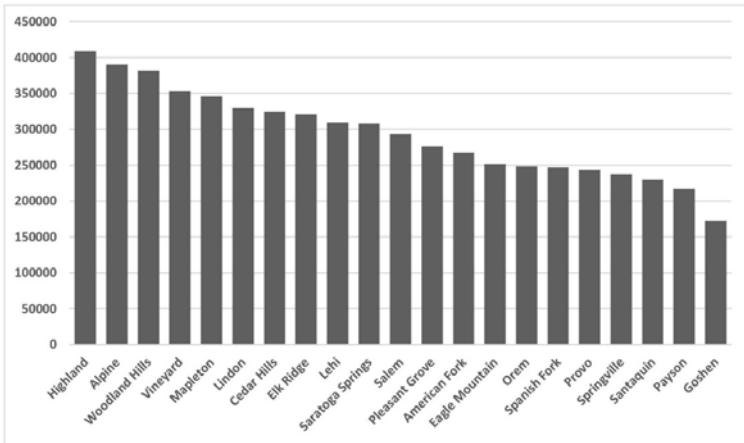


Figure 1. Average selling price by city, 2014–2016

Other factors (other than price) may also indicate a real estate market entering or currently experiencing a bubble. One such factor is the time it takes to sell a house. During a hot market, when demand is greater than supply, one expects houses to sell more quickly. The same effect may occur based on specific supply and demand functions at the city level. Figure 2 reports the median number of days a house has been on the market for each of the previously listed cities. American Fork, Provo, and Eagle Mountain have the shortest marketing periods (23, 23, and 25 days, respectively); Mapleton, Woodland Hills, and Vineyard have the longest marketing periods (60, 61, and 65 days, respectively) when looking at data from 2014–2016.

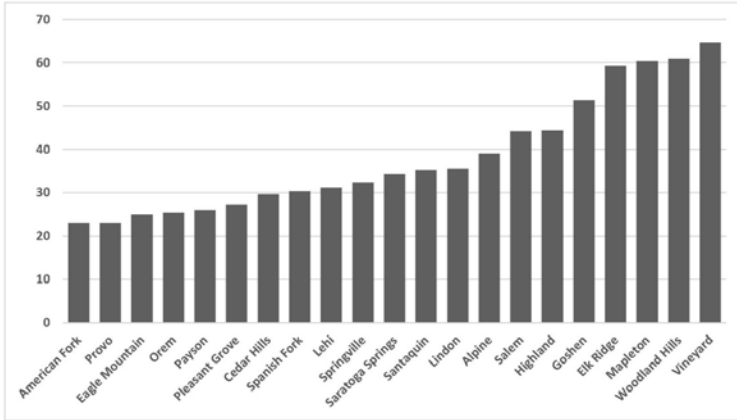


Figure 2. Median days on market, 2014–2016

A third factor that may indicate the strength of a housing market is the number of houses sold. Figure 3 plots the average number of transactions by city for the 2014–2016 period. Lehi, with 883 transactions, comprises 13.5% of the market and ranks the highest. Eagle Mountain ranks as the second most active market, with 665 transactions. The volume of transactions and the number of homes in each city are expected to be highly correlated. Although we do not control for the number of houses in each city, comparing each city across time (as reported in Table 2) will inherently control for variations in the number of houses.

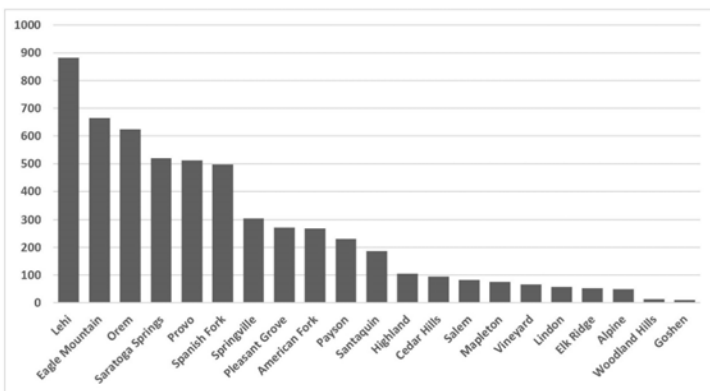


Figure 3. Average number of home sales by city, 2014–2016

Table 2 reports the three measures pictured in Figures 1–3 for the years 2014–2016. If the housing market were entering a bubble, we would expect either the number of transactions to increase, the mean sale price to increase, the number of days on the market to decrease, or a combination of the above when analyzing naïve measures of the real estate market. Casual observation of Table 2 does not suggest a striking pattern in any of these variables. We will leave in-depth analysis of the city-level data to the reader. In the next section, we examine the three factors (i.e., price, days on market, and number of houses sold) in the aggregate over time.

Table 2. Measures of market strength by city, 2014–2016

City Name	2014			2015			2016		
	Number Sold	Average Sale Price	Days on Market	Number Sold	Average Sale Price	Days on Market	Number Sold	Average Sale Price	Days on Market
Alpine	58	390,221	48	42	383,588	46	51	396,406	24
American Fork	265	247,201	32	267	268,393	22	277	289,278	15
Cedar Hills	92	307,539	35	90	319,896	34	104	347,383	20
Eagle Mountain	592	231,741	35	681	250,599	25	720	272,804	15
Elk Ridge	38	284,748	54	61	330,956	70	58	346,812	54
Goshen	15	171,890	113	6	154,667	30	10	190,430	12
Highland	98	403,918	51	107	414,441	38	111	409,176	44
Lehi	816	290,926	48	906	310,338	27	927	327,091	19
Lindon	58	303,921	46	49	333,991	42	64	351,819	19
Mapleton	85	330,670	89	72	349,451	41	72	358,747	51
Orem	574	230,897	39	652	250,718	21	645	264,984	16
Payson	203	203,013	33	227	216,544	26	266	232,488	19
Pleasant Grove	263	265,258	40	285	279,344	22	269	284,366	20
Provo	456	224,856	32	488	244,127	21	591	262,355	16
Salem	74	282,648	44	72	289,711	52	105	309,947	37
Santaquin	150	205,778	51	206	230,830	35	208	252,568	20
Saratoga Springs	456	284,774	43	506	308,383	32	596	331,714	28
Spanish Fork	436	226,372	42	542	248,461	27	514	267,291	22
Springville	286	224,580	53	308	231,252	24	320	258,373	21
Vineyard	39	352,053	78	82	333,741	50	78	375,117	66
Woodland Hills	17	355,726	65	12	407,567	52	14	382,357	66

Naive Measures in the Aggregate

Figure 4 plots the number of transactions across time. The chart reveals a cyclical effect in the frequency of housing transactions. Years 2000–2006 show an increasing trend in the number of homes sold, followed by a significant decline during the recession from 2006 to 2009. After 2009, we see a significant increase in the volume of transactions and a continuing upward trend through 2016.

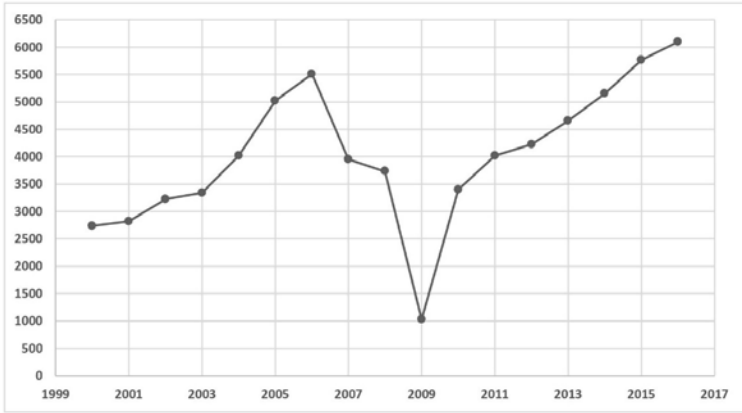


Figure 4. Total number of home sales, 2000–2016

Figure 5 plots the days on market across time. Other than an upward blip during the housing crisis, there is a decreasing trend for the median days on market, indicating a housing market that is heating up.

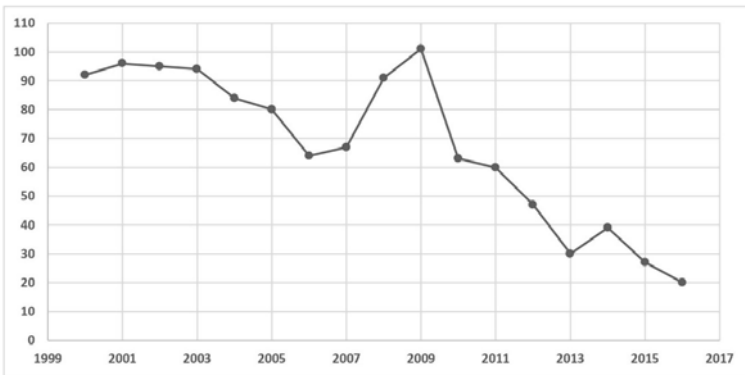


Figure 5. Median days on market, 2000–2016

The final factor we consider is sales price over time. Figure 6 presents the naïve index of listing prices and transaction prices by year. Depending on the skill of real estate brokers and their ability to dictate the listing prices of homes to their selling clients, we may predict three patterns when comparing list with sales prices. If real estate brokers have the skill to judge market demand and if they can convince selling clients of this skill, then as demand and supply change, we would ex-

pect the difference between the two lines to stay relatively constant. If sellers reject the counsel of brokers to listing prices during soft markets, or if brokers set housing prices too high because of lack of skill, we would expect the lines to diverge in slower real estate markets. On the other hand, if prices are set too low as the result of a booming market, then we would expect the two lines to converge. Figure 6 indicates that the differential between the list and sales price has remained fairly constant over the sample period.

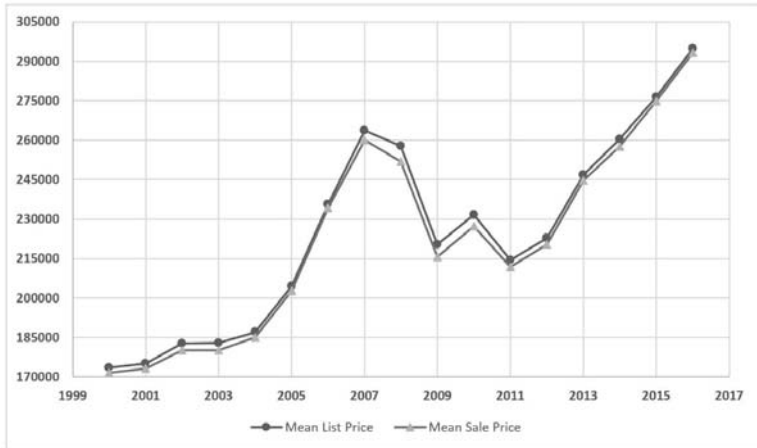


Figure 6. List and transaction housing prices, 2000–2016

Continuing to examine transactions prices, Figure 7 reports the naïve index that we will compare with our hedonic index. Instead of reporting the actual prices, we report the percent change from the base year (2000), which is standardized to one. The graph indicates that over the sample period, housing prices have appreciated 70%. We see significant periods of growth during 2004–2007 and 2011–2016, and we see a period of decline between 2007 and 2011. An interesting point to mention is the increase in sale price during 2010 that seems to dampen the perceived effect of the recession on the Utah County housing market.

The preceding data highlight the potential hazard of using a naïve index. Basing conclusions on the naïve index does not control for the quality characteristics of the houses being sold. Perhaps larger houses have been sold currently relative to the years 2007–2011. If so, the increase in housing prices may be attributed to larger houses, not to supply and demand pressures that define a strong or weak real estate market. Perhaps, by pure randomness, older homes tended to transact

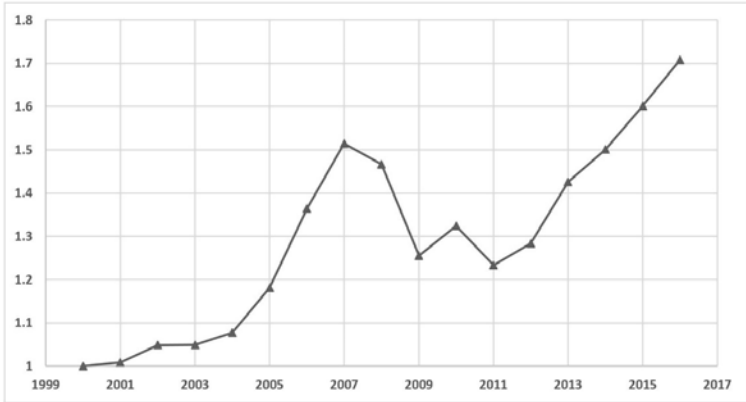


Figure 7. Naïve pricing index for Utah County houses, 2000–2016

less frequently the past five years. Again, the price decline may not be a market effect, but a quality effect—age, in this example. In the next section, we create a hedonic pricing index to control for varying qualities of the houses being sold in Utah County.

3. Hedonic Model and Empirical Methodology

Hedonic regression analysis provides the basic framework for the pricing section of this study by recognizing that the response variable, in this case the sales price of a home, is determined by several explanatory variables (see Colwell and Ditmore [1999] and Goodman [1998] for the history of hedonic price analysis). The regression analysis estimates the marginal values or implicit prices of the individual price determinants. Following the framework used by Guttery and Sirmans (1995), the hedonic model is specified as follows:

$$\begin{aligned} \text{LNPRICE} = & \alpha_0 + \alpha_1 \text{LNSQFTABOVE} + \alpha_2 \text{LNSQFTBSMT} + \\ & \alpha_3 \text{BSMTFIN} + \alpha_4 \text{LNAGE} + \alpha_5 \text{LNGARAGE} + \alpha_6 \text{LNLOT} + \\ & \sum_{i=2000}^{2016} \beta_i \text{CITY}_i + \sum_{i=2000}^{2016} \delta_i \text{YEAR}_i + \varepsilon \end{aligned}$$

where LNPRICE is sales price of the property (natural log), LNSQFTABOVE is square feet of total building area above ground (natural log), LNSQFTBSMT is square feet of total building area below ground (natural log), BSMTFIN is the percentage of the basement that is finished, LNAGE is the age of the house in years (natural log), LNGARAGE is the capacity of the garage or carport measured in num-

ber of vehicles (natural log), LNLOT is the square feet of total lot area (natural log), $CITY_i$ is the city fixed effects, and $YEAR_i$ is the year fixed effects.

The hedonic regressors address the quality differences in the data by holding the marginal values fixed. Controlling for quality characteristics allows the coefficients on the year dummy variables to capture the intertemporal price effects. The index is constructed by normalizing the antilogarithm or the dichotomous time variables to unity.

We choose to take the natural logarithm of most of the regressors to allow for non-linearity in their functional form. In other words, we allow for diminishing marginal returns. As an example, the marginal value of an additional 100 square feet in a 10,000-square-foot home is less than the marginal value of an additional 100 square feet in a 500-square-foot home. Using natural logarithms for this purpose is widely accepted in the hedonic pricing literature (see Slade, 2000).

4. Hedonic Index Empirical Results and Comparison with Naïve Model

The results of the regression are reported in Table 3. We predict a positive sign on the estimated parameter for the size of the house (both above and below ground), the percentage of the basement that is finished, the size of the garage, and the size of the lot. We predict negative relationship between the age and the price of the house. The results in Table 3 are consistent with these predictions, all with p-values of <1%.

As an example of how one interprets the coefficients (i.e., their marginal impacts), consider the square footage above ground variable. Because of the natural logs, a 1% change in the price of above square footage would lead to a 0.532% change in the sales price. For instance, if a property sold for the average sales price of \$230,000 and an average square foot above ground of 1,700, a 1% increase in size is 17 square feet. The estimated parameter of 0.532% change in sales price is \$1,223.60. When divided by 17 square feet, this equals \$72 per square foot. Thus, each square foot of housing area above ground represents an additional \$72 in transaction value.

Table 4 reports regression results of an expanded model, where we include the impact of bedrooms and bathrooms to check for robustness. All of our results from Table 3 are robust to the added variables. The results indicate an additional bathroom adds approximately nine times the value of an additional bedroom (coefficients of 0.0126 vs. 0.0942).

Table 3. Hedonic regression index results, 2000-2016

Variable	Estimated Parameter	Standard Error	t-stat	P-value	VIF
Intercept	7.0977	0.0192	369.1	<.0001	0.0
Ln(square feet above ground)	0.5320	0.0025	211.5	<.0001	1.5
Ln(square feet of basement)	0.0289	0.0003	102.1	<.0001	1.6
Percent of basement finished (%)	0.0009	0.0000	54.1	<.0001	1.7
Ln(age of pperty when sold)(years)	-0.0318	0.0003	-102.5	<.0001	1.6
Ln(capacity of the garage/carport)	0.0204	0.0004	55.1	<.0001	1.3
Ln(size of lot in square foot)	0.0899	0.0015	61.8	<.0001	1.3
Alpine	0.2310	0.0063	36.6	<.0001	1.2
American Fork	0.0503	0.0032	15.8	<.0001	1.7
Cedar Hills	0.1010	0.0043	23.5	<.0001	1.3
Eagle Mountain	-0.1174	0.0026	-45.3	<.0001	2.0
Goshen	-0.2924	0.0204	-14.3	<.0001	1.0
Highland	0.2064	0.0044	46.5	<.0001	1.4
Lehi	0.0721	0.0025	29.0	<.0001	2.5
Lindon	0.1121	0.0057	19.7	<.0001	1.2
Mapleton	0.0637	0.0062	10.3	<.0001	1.2
Orem	0.0287	0.0027	10.6	<.0001	2.6
Payson	-0.0936	0.0034	-27.9	<.0001	1.6
Pleasant Grove	0.0453	0.0033	13.7	<.0001	1.7
Provo	0.0543	0.0030	18.4	<.0001	2.5
Salem	-0.0172	0.0055	-3.1	0.0017	1.2
Sataquin	-0.1603	0.0040	-39.8	<.0001	1.3
Spanish Fork	-0.0442	0.0027	-16.2	<.0001	2.1
Springville	-0.0271	0.0032	-8.6	<.0001	1.8
Vineyard	0.0238	0.0087	2.7	0.0062	1.1
Woodland Hills	0.0166	0.0160	1.0	0.3001	1.0
2001	0.0187	0.0040	4.7	<.0001	1.9
2002	0.0263	0.0040	6.6	<.0001	2.1
2003	0.0296	0.0039	7.6	<.0001	2.1
2004	0.0685	0.0037	18.3	<.0001	2.3
2005	0.1504	0.0036	41.5	<.0001	2.7
2006	0.3211	0.0036	88.6	<.0001	2.8
2007	0.4527	0.0036	125.2	<.0001	2.3
2008	0.3914	0.0037	104.6	<.0001	2.3
2009	0.2728	0.0055	49.6	<.0001	1.4
2010	0.1982	0.0040	49.1	<.0001	2.2
2011	0.1263	0.0040	31.9	<.0001	2.4
2012	0.1750	0.0039	44.7	<.0001	2.4
2013	0.3056	0.0037	82.6	<.0001	2.6
2014	0.3664	0.0035	103.6	<.0001	2.7
2015	0.4380	0.0034	128.9	<.0001	2.9
2016	0.5160	0.0033	155.4	<.0001	3.1
Adjusted R ²	0.8346			<.0001	

Table 4. Hedonic regression index results, 2000–2016					
Variable	Estimated Parameter	Standard Error	t-stat	P-value	VIF
Intercept	7.4529	0.0221	337.6	<.0001	0.0
Ln(sq. ft. above ground)	0.4668	0.0033	140.2	<.0001	2.6
Ln(sq. ft. of basement)	0.0285	0.0003	101.4	<.0001	1.6
% basement finished	0.0006	0.0000	24.4	<.0001	2.8
Ln(age of property when sold) (yrs)	-0.0301	0.0003	-97.2	<.0001	1.7
Ln(capacity of garage/carport)	0.0178	0.0004	47.6	<.0001	1.3
Ln(size of lot in sq. ft.)	0.0948	0.0015	64.4	<.0001	1.4
Ln(no. bedrooms)	0.0106	0.0035	3.0	0.0027	2.3
Ln(no. bathrooms)	0.0942	0.0028	33.4	<.0001	2.7
City Fixed Effects	Yes				
Yearly Fixed Effects	Yes				
Adjusted R ²	0.8381			<.0001	

The yearly dummy variables are used to construct the hedonic price index. The estimated coefficients are in logarithmic form. To construct the hedonic index, we take the antilogarithm (i.e., the exponential of the coefficient) to estimate the data points for Figure 8 from the hedonic regression annual dummy variables. To construct the naïve index, we use the annual mean sale price for each year and construct a percent return as $[\text{Price}_t/\text{Price}_{t-1}]-1$. The base year (2000) is the omitted variable and is indexed to one.

Figure 8 plots the hedonic versus the naïve index with the same model used by Brau and Slade (2001). Comparing the two illustrates the need to adjust for quality characteristics. Recall our earlier examination of the years 2009–2010. The naïve index may suggest that housing prices began rebounding from the recession in 2010. When correctly adjusted by the hedonic methodology, the cumulative price

difference during 2009–2010 is negative, contrasting the positive increase indicated by naïve model.

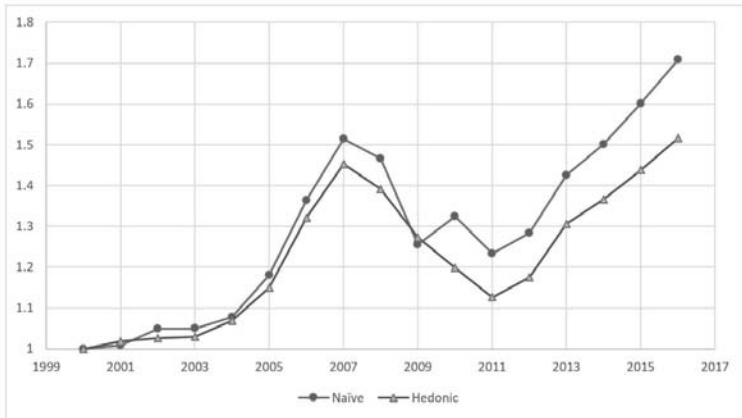


Figure 8. Hedonic vs. naïve pricing index for Utah County houses (2001 model), 2000–2016

The second major benefit of using the hedonic methodology is the calculation of housing appreciation. Tracking the return of investment is important and should be done as accurately as when calculating an individual's net worth. At times, the two indices are very similar, such as in the year 2004. However, at other times, the naïve index inflates the actual appreciation of housing prices. For example, in 2016, the naïve index reports a 71% cumulative return since the base, but the hedonic index indicates that after correcting for quality, the actual return is 52%.

4. Conclusion

We have analyzed the Utah County housing market using a sample of 70,462 single-family residential transactions from the years 2000–2016. We find that a naïve pricing model indicates over a 70% growth in price over that 17-year span. Next, we construct a hedonic pricing model and show that after controlling for characteristics of the property, the actual price increase is about 50%. Adjusting this growth to an annual rate, Utah County single-family dwellings have experienced a 2.5% annual appreciation from 2000 through 2016 ($1 - (1.025^{17}) = 52\%$). Overall, our study shows that single-family dwellings have increased in line with historical rates over our sample period

and not at a real estate bubble pace as suggested by some business press.

References

- Brau, J. and B. Slade, "An Examination of Utah County Housing Trends Comparing Naive Index Methods to Hedonic Constant-Quality Index Methods." *Journal of the Utah Academy*, Vol. 78 (2001), pp. 65–78.
- Colwell, P. and G. Ditmore. "Who Was First? An Examination of an Early Hedonic Study," *Land Economics*, Vol. 75, No. 4 (1999), pp. 620–626.
- Gatzlaff, D. and D. Ling. "Measuring Changes in Local House Prices: An Empirical Investigation of alternative Methodologies," *Journal of Urban Economics*, Vol. 35 (1994), pp. 221–244.
- Goodman, A. "Andrew Court and the Invention of Hedonic Price Analysis," *Journal of Urban Economics*, Vol. 44, (1998), pp. 291–298.
- Guttery, R. and C.F. Sirmans. "Creating a Constant-Quality Index for Small Multifamily Rental Housing," *Journal of Real Estate Research*, Vol. 10, (1995), pp. 557–567.
- Kusisto, L. (2017, April 26). "Rising Home Prices Raise Concerns of Overheating." *Wall Street Journal*. Retrieved April 3, 2017 from <https://www.wsj.com/articles/rising-home-prices-raise-concerns-of-overheating-1493128355>.
- Kusisto, L. (2017, April 25). "U.S. Home-Price Growth Continued Accelerating in February." *Wall Street Journal*. Retrieved April 3, 2017 from <https://www.wsj.com/articles/u-s-home-price-growth-continued-accelerating-in-february-1493125220>.
- Slade, B. "Office Rent Determinants During Market Decline and Recovery," *Journal of Real Estate Research*, Vol. 20, No. 3 (2000), pp.357–380.

The Uncertain Future of LIFO

Jennifer Harrison, Chelsea Dye, and Dara Hoffa

Westminster College

Abstract

LIFO, the accounting concept of “last-in, first-out” inventory costing, started in the early 20th century and saw remarkable expansion within several industries within the United States. Use of LIFO has been particularly dominant within the American oil and gas industry. However, recent political and cultural forces may see the end of this highly utilized principle of accounting practice. This paper tracks the history of LIFO, analyzes the possible changes to the methodology, and advocates for a broad-spectrum preparation against seemingly likely changes to this basic accounting procedure.

LIFO—the accounting concept of “last-in, first-out” inventory costing—has been a mainstay of U.S. companies for almost a century. Firms use this technique to better match current revenues to current expenses. As most firms face ever-increasing input costs, LIFO accounting lowers tax liabilities for firms as they are able to expense current, generally higher costs.

Unfortunately, LIFO is a potential target for opportunistic use from the federal government. A widespread repeal of LIFO could result in billions of dollars in increased tax revenue for a government striving to balance its budget. The oil and gas industry would be most impacted by a LIFO repeal. Not surprisingly, LIFO is on the short list for possible government regulatory changes. Many within the accounting profession are concerned about the dramatic implications from an immediate and ubiquitous repeal of LIFO. Influencing the manner in which such a repeal would take place is important for accounting professionals to consider.

The purpose of this paper is to highlight the critical role LIFO plays in the financial well-being of US companies and to consider methods for facing LIFO repeal. The paper briefly reviews pertinent aspects of the history of LIFO as well as recent events that may have precipitated the federal government's interest in repealing LIFO. Then the paper outlines various approaches that accounting professionals may consider for facing LIFO reform—including lengthening the tax liability period, decreasing the tax rate, eliminating the LIFO conformity rule, adopting only portions of the international standards, avoiding international financial reporting standards (IFRS) adoption, or proactively reducing LIFO reserves. Implications of these approaches are discussed for the U.S. government, economy, and the accounting profession.

The History of LIFO

LIFO, an acronym meaning last-in first-out, makes certain assumptions about accounting cost flow, using the latest costs acquired as the first costs out. Although not utilized as a methodological paradigm until the 1930s, the concept likely predates the 20th century (Davis, 1982).

The concept began with the “base stock method,” a framework that presumed a company to have a minimum (or base) stock necessary for operations (Chatfield and Vangermeersch, 1996). That minimum stock operated as its normal stock and functioned as a continuous investment and any change in value in that normal stock could be disregarded (Chatfield and Vangermeersch, 1996). The inventory that a company possessed above the minimum became a temporary investment intended for immediate resale and any goods that the company sold would count as coming from that amount above the normal stock (Davis, 1982). The first company in the United States to adopt this accounting method was The American Smelting and Refining Company in 1903 (Chatfield and Vangermeersch, 1996). Ten years later, the Na-

tional Lead Company became the second company to adopt the base stock method (Chatfield and Vangermeersch, 1996). As lead does not decay, rust, or rot, National Lead could move out the oldest materials first; however, to avoid excess handling of the lead, they preferred to load the most recently acquired materials first into the manufacturing process (Davis, 1982). Further, because manufacturing white lead entailed a 5- to 6-month process, a certain amount always needed to be in the pipeline. Their minimum inventory served as permanent investment (Davis, 1982).

H.T. Warshow, a company officer, explained how the National Lead used the Base Stock Method (Warshow, 1924). According to Warshow, National Lead would write down their inventory if it fell below the 1913 book value; at that point, the company would then write down the inventory to the new market price. Moreover, if the quantity of ending inventory exceeded the base stock, National Lead would value that excess using a conventional costing method. If the company dipped into the base stock as part of their operations, the use of those goods operated as a borrowed loan. When the goods returned to the base stock, the company purchased them at market value, charged that market value to cost of goods sold, and then subtracted the goods from inventory. National Lead preferred using the base stock method as it allowed for smoother profit accumulation than the then-standard procedure, because current revenues matched up against current expenses. However, at the time the Internal Revenue Service (IRS) did not allow this accounting innovation, thus National Lead kept two accounting records—one for tax purposes and the other for financial reporting purposes (Warshow, 1924).

During the 1920s and 1930s, the base stock method encountered various challenges from the U.S. government. The Treasury prohibited its use for tax purposes in 1919, and in the 1930 Supreme Court case of *Lucas v. Kansas City Structural Steel Company*, 281 U.S. 264 (1930), the Court held that considering base stock for tax purposes lacked merit, as no clear line separated base stock from other inventories. This created a situation where the manipulation and distortion of income became much simpler. In 1936, the American Petroleum Institute Committee worked with a committee from the American Institute of Accountants, agreed that LIFO valuation for oil companies' inventories could operate as an acceptable accounting principle (Davis, 1982). This marked the first time that an accounting body accepted the concepts of LIFO (Davis, 1982).

The U.S. Congress first addressed the LIFO issue in 1938 when they allowed LIFO for tax purposes for certain industries, but did not include petroleum (Base Stock Inventories and Federal Income

Taxation, June 1936). Furthermore, the 1939 Revenue Act created the conformity rule that required any company adopting LIFO for tax purposes to also use it for financial reports. That bilateral balance provided evidence to the taxpayers that LIFO accurately reflected actual income. However, the 1939 Revenue Act still limited LIFO to certain industries. In 1947, the tide turned when the Tax Court ruled that all taxpayers could operate under LIFO if desired (cf., *Hutzler Brothers Company v. Commissioner*, 8 T.C. 14, Tax Court, 1947). Much later, in 1981, the IRS modified the LIFO conformity rule to allow taxpayers to use any method for valuing asset inventory on the balance sheet as long as the taxpayer used LIFO for income purposes (26 CFR §1472-2(e)). The IRS also allowed for supplementary disclosure on any basis as long as the primary income presentation occurs via LIFO (26 CFR §1472-2(e)).

Recent Events

After years of acceptance of LIFO for tax and financial reporting purposes, a number of events during the early years of the 21st century brought the LIFO apparatus of inventory cost flow accounting into question: 1) the increase in U.S. government spending; 2) the increased tension between the U.S. government and the oil and gas industry, and 3) the continued convergence of United States accounting standards (US GAAP) to international accounting standards. Separately, each of these events heralded a marked change making the repeal of LIFO a plausible occurrence. Combined, these events created an atmosphere in which the question of LIFO repeal becomes a matter of when, not if.

Increased U.S. Government Spending

Like any country with a complex national economic system, the United States copes with periods of both growth and decline. With the latest financial crisis rooted in the subprime mortgage debacle, the U.S. economy struggled through the Great Recession beginning in 2008. During this time of slow economic growth and activity, the typical economic impacts of a recession occurred: a slowdown in hiring employees, an increase in terminations, a decline in capital investments, and reductions in consumer spending. Concomitantly, healthcare costs continued to rise and influence the news cycle, as the nation and Congress debated the very nature of the healthcare system in the United States with the introduction of the Affordable Care Act (ACA). Although the impact of the ACA on the U.S. recession recovery remains a matter of argument, its adoption does illustrate the foundational assumptions of the U.S. federal government at the time—the U.S. federal government

was planning for and implementing additional expansive government-run programs during a time of recession.

The combination of a slowing economy and increasing government outlays fostered an even more urgent need for a commodity that governments rarely have enough of—revenues. Figures 1 and 2 display the U.S. government spending and revenue levels from 1970 to (forecasted) 2020. Note the increased spending and decreased revenues (surrounding the 2010 axis labels).

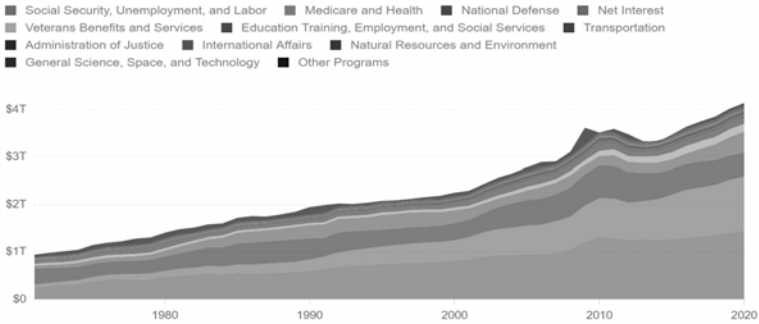


Figure 1: U.S. government spending (actual and forecasted) (Inside Gov, 2016)

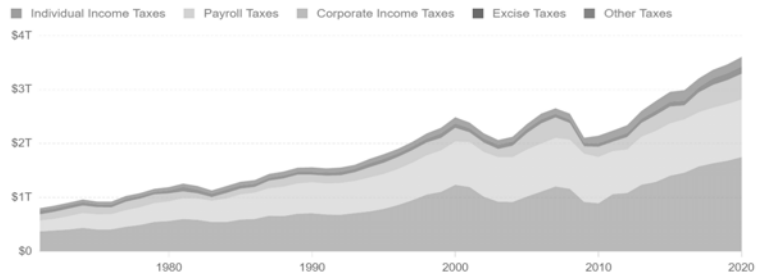


Figure 2: U.S. government revenues (actual and forecasted) (Inside Gov, 2016)

Faced with increased spending and decreased revenues, the proposed federal budgets during this period contained many options on increasing tax revenue. Of interest within this paper appears the option to repeal the LIFO accounting method. A repeal of LIFO would involve disallowing companies the use of LIFO for calculating taxable income. Assuming an inflationary environment, the result of repealing LIFO would be increased taxable income as the higher, “last-in” costs would not be used to offset revenues. Instead, the lower, “first-in” costs would

be used to offset revenue—resulting in higher taxable income, higher taxes, and more revenue for the federal government. A federal government in need of increased revenues, combined with factors discussed below, created a setting in which the demise of LIFO seemed possible.

Backlash on Oil and Gas Industry

Of all the sectors of US economic activity, the oil and gas industry would bear the largest burden in undergoing a repeal of LIFO. The relationship between the U.S. government and the oil and gas industry dates back to the middle of the 19th century. In those early years, the government provided tax breaks for exploration and development of fuel sources. Additionally, the government helped, perhaps indirectly, to promote the industry by building interstate roads, constructing bridges, and laying rail lines for the improvement of transportation. However, in more recent years, strain and tension appeared in the bond between the U.S. government and the oil and gas industry. During the period of national-security concerns, climate-change fear, carbon tax vs. carbon cap-and-trade debates, ethanol and other alternative-fuel initiatives, the U.S. government significantly altered its stance on the dominance of and dependence on oil and gas. Add to these political trends the cultural effects of 1989 Exxon Valdez oil spill, the BP Gulf coast oil spill in 2010, and the record high profits that Exxon Mobil and other oil companies had in 2006 (Krauss, 2007), and the complete reversal of political opinion seems inevitable. Gone are the days of favored-industry status; oil and gas has become a targeted industry to be controlled and taxed at increasing levels.

Specific to LIFO, proposed U.S. budgets published by the Congressional Budget Office (CBO) have included, for several years, an option to repeal the LIFO inventory accounting method (Congressional Budget Office, 2015). Such a repeal would increase government revenues as companies currently using LIFO would be required to recognize, and be taxed on, the deferred revenues represented by their LIFO reserves. LIFO reserves represent the difference between the inventory valued under LIFO and what it would be valued at under FIFO. By some estimates, energy companies hold one-third of those LIFO reserves (Leone, 2010). Companies that utilized LIFO for the longest period of time and that also experienced inflationary costs would pay the most taxes under a LIFO repeal. Per the CBO 2015 budget, the increased revenue from repeal of LIFO for the years 2015 to 2024 is shown in Table 1.

Table 1: Estimated tax revenue from LIFO repeal with calculated oil and gas portion

Years	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2015-2024
Billions \$ Increase	13	26	26	26	14	2	2	2	2	2	115
<i>Oil & Gas Increase</i>	<i>4.4</i>	<i>8.8</i>	<i>8.8</i>	<i>8.8</i>	<i>4.8</i>	<i>0.7</i>	<i>0.7</i>	<i>0.7</i>	<i>0.7</i>	<i>0.7</i>	<i>39.1</i>

By applying the estimate noted earlier of one-third of the LIFO reserves being held by energy companies to the federal government's estimated LIFO repeal tax increase, an estimated financial impact (increase in taxes) to this industry sector accumulates to \$39.1 billion from 2015 to 2024. For 2015-2016, the total LIFO income would have been \$39 billion whereas the total revenue of the U.S. during that time period was \$6.5 trillion (The White House, 2017). Had that income been included during those two years, it would have represented roughly 0.6% of the total federal revenue. The threat of LIFO repeal, with its related increase in taxes, served as enough of a catalyst for numerous companies currently using LIFO inventory accounting to create a lobbying group—The LIFO Coalition. With no past or pending repeal of LIFO by Congress, its continued inclusion in proposed budgets makes it a more commonly considered option for the federal government to use as a tool for decreasing the U.S. government deficits.

U.S. Convergence with International Accounting Standards

The Financial Accounting Standards Board (FASB) and International Accounting Standards Board (IASB) convergence project emerged on the scene in parallel with the 2008 recession and the political and cultural change regarding the oil and gas industry. Beginning in 2002 with the Norwalk Agreement, this project's lofty goal aimed to tackle some of the biggest obstacles preventing the adoption of IFRS by the U.S. Global accounting standards would facilitate comparison of publicly traded companies, thus allowing for more efficient and accurate allocation of capital globally.

The initial Norwalk agreement was updated in 2006 and 2008, with updates on the various topics under consideration. These topics included complex and highly debated items such as revenue recognition, fair value accounting, and leases. Of note, the topic of inventory valuation did not emerge as a convergence topic—even though it was (and is) a well-known difference between IFRS and U.S. GAAP. Specifically, IFRS does not allow use of LIFO costing method, while U.S. GAAP does. Thus, with complete adoption of IFRS, publicly traded U.S. companies using LIFO would then be disallowed from the continued use of LIFO for financial statement purposes. This fact alone would likely not cause too much of a backlash from U.S. LIFO-using companies. However, because of the LIFO conformity rule—companies that use LIFO for tax purposes must also use it for financial statement purposes—this is of great concern to U.S. LIFO-using companies. Without the ability to use LIFO for financial purposes, no company would have the ability to use it for tax purposes.

While the topic of LIFO inventory was ignored in the official IFRS/U.S. GAAP convergence project, it received discussion by the U.S. governmental agency that oversees the FASB in its accounting standards creation duties—the Securities and Exchange Commission (SEC). The SEC, during the convergence project period, considered the appropriate use of IFRS by U.S.-based companies. In 2008, the SEC published a “Roadmap for the Potential Use of Financial Statements Prepared in Accordance with International Financial Reporting Standards by U.S. Issuers,” which provided several milestones that were to be met by the convergence project and encouraged further work by the IASB and FASB in accomplishing them. Then in 2012, the SEC published “Work Plan for the Consideration of Incorporating International Financial Reporting Standards into the Financial Reporting System for U.S. Issuers”. In both reports, the SEC noted that LIFO is not allowed by IFRS but is by U.S. GAAP, causing a variance in accounting standards.

These events—a sluggish economy, a changing political environment, a shifting of cultural mores, and IFRS/U.S. GAAP convergence—combined to create an environment fertile for the continued debate of LIFO policies.

Methods of Facing LIFO Repeal

At the heart of disallowing LIFO as an inventory costing method lies the financial impact of the switch from LIFO to other inventory costing methods—namely FIFO (first-in, first-out) or average costing. Typically, a company’s change from LIFO to another inventory costing

method will cause an increase in inventory value and an increase in taxable income, and thus, a tax liability. As stated earlier, the increased taxable income across the entire economy is estimated to be in the billions of U.S. dollars, resulting in billions of additional tax revenues to the U.S. government. Assuming the desirability of mitigating or eliminating the increased tax liability of a LIFO repeal, several effective options exist for doing so. These options include lengthening the tax liability period, decreasing the tax rate, eliminating the LIFO conformity rule, adopting only portions of the international standards, avoiding IFRS adoption, or proactively managing LIFO inventory.

Lengthen the Tax Liability Period

Currently, the IRS tax code allows for a 4-year period in which a company may spread out the effect of an accounting change that increased its tax liability. This IRS rule could be amended to allow for an extended period, perhaps over 10 years. Although it would not reduce the total tax burden, this has the effect of decreasing the annual cash outlays required.

Decrease the Tax Rate

Another option could be to amend the U.S. tax code to allow a reduced tax rate on all additional tax liabilities caused by a switch from LIFO to another inventory costing method. With a lower tax rate, the additional tax liability could be either slightly lessened or significantly lessened depending on the given tax rate.

Eliminate the LIFO Conformity Rule

To some extent, companies already keep two sets of accounting records, one for financial statement purposes and the other for tax determination. The existence of the LIFO conformity rule requires that one aspect of these two sets of accounting records be the same, namely the inventory costing method if LIFO is used for financial statement purposes. Should the LIFO conformity rule be removed from the Internal Revenue Code, companies using LIFO for tax determination could also be in compliance with IFRS accounting rules by using another inventory costing methods for financial statement purposes. The additional benefit to this method follows that no additional tax liability would be recognized with the continued use of LIFO for tax determination.

Adopt IFRS “Lite”

Although the main goal of the IFRS/U.S. GAAP convergence project centered around the adoption of international accounting standards by the U.S., the functional trends allowed for countries adopting IFRS to do so only partially. The U.S. could follow suit and simply adopt those portions of the international accounting standards that do not cause undue burden on U.S. companies. Much progress has been made in the effort to make financial statements more comparable across country borders. But in reality, there are even differing accounting options within U.S. GAAP (and other country’s accounting standards) allowing companies to use the available rules that best present their financial status. One of those areas allowing varying accounting options is the use of inventory cost method. Even with the removal of LIFO, the other methods of FIFO, weighted average, or specific identification still exist. Current U.S. GAAP requires that companies using LIFO provide information within the notes to the financial statements that allow a reader to recalculate the financial statements as if the company used the FIFO inventory costing method. Experienced financial statement users are familiar with this information, and the calculation to convert from LIFO to FIFO remains simple for those understanding its purpose and meaning. By adopting IFRS “Lite,” U.S.-based companies would essentially not be required to discontinue LIFO to be in compliance with IFRS accounting standards. However, these companies might still need to lobby to ensure that LIFO not be disallowed for tax determination.

Do Not Adopt IFRS

This option extends the prior possibility. The entities that create U.S. accounting standards could separate themselves from the international accounting standards arena. Instead, the U.S. could continue to publish high-quality accounting standards that follow the accounting concepts originated by the FASB starting in 1973. By promulgating accounting standards based on a set of sound accounting concepts, the U.S. could continue to influence other country’s accounting standards and practices. Again, this option would allow companies to continue using LIFO with no concern of not following required financial statement accounting standards. However, companies may eventually lose the ability to use LIFO because of a rule change for tax determination—which is ultimately the more pressing issue.

Lobby, Lobby, Lobby

Although this paper has focused on the impact of LIFO repeal on the oil and gas industry, there is a surprising array of industries that use LIFO, such as the chemical, pharmaceutical, and groceries industries. As claimed by the LIFO Coalition, one-third of all U.S. companies use LIFO. Given the political and culture changes of the last 30 years, businesses that could be affected by a LIFO repeal would be wise to expend resources in lobbying various parts of the federal government, from the IRS, to Congress, to the Presidency in changing the current LIFO conformity rule.

Actively Manage LIFO Inventory

Rather than rely on action from the U.S. government or the accounting profession, companies currently using LIFO could proactively start reducing their inventory levels. By doing so, companies can control the timing and impact of recognizing LIFO liquidation revenues—and the related taxes. This action, if significant enough industry wide, could have the added benefit of reducing the attractiveness of a LIFO repeal to a revenue-hungry U.S. government. Of the options to mitigating a LIFO repeal discussed herein, this option has the benefit of being entirely within the control of company management. However, in addition to taking action based solely on tax liability, management must consider the impact of voluntary inventory reductions on company metrics such as current ratio, reported net income, future cash flows, and even investor relations.

High-level analysis using oil and gas industry data provides insight into additional management action to mitigate the impact of a LIFO repeal. Extrapolating this oil and gas analysis also generates some interesting options available to any company currently using LIFO.

Unlike inventory cost for most consumer goods, which have an inflationary trend, crude oil prices are volatile. Within the past 10 years crude oil prices have reached a height of over \$140.00 per barrel to a low of around \$27.00 (Figure 3). Interestingly, the LIFO reserves of oil and gas companies, as represented in the below chart using ExxonMobil, Chevron, and ConocoPhillips (the three largest U.S.-based oil companies), have had a similarly volatile history (Table 1). By combining year-end crude oil prices from Figure 3 and total LIFO reserves for ExxonMobil, Chevron, and ConocoPhillips, it becomes apparent that these metrics have experienced similar volatility (Figure 4).



Figure 3: West Texas Intermediate Crude Oil Prices. Source Crude Oil Price History

Table 1: Oil and Gas LIFO Reserves vs. Taxes on Reserve, 2012-2016					
	2016	2015	2014	2013	2012
ExxonMobil					
LIFO Reserve (Millions \$)	8,100	4,500	10,600	21,200	21,300
Taxes on reserves (\$)*	2,835	1,575	3,710	7,420	7,455
Chevron					
LIFO Reserve (Millions \$)	2,942	3,745	8,135	9,150	9,292
Taxes on reserves (\$)*	1,030	1,311	2,847	3,203	3,252
ConocoPhillips					
LIFO Reserve (Millions \$)	104	6	6	160	200
Taxes on reserves (\$)*	36	2	2	56	70
Total					
Total Reserves (Millions \$)	11,146	8,251	18,741	30,510	30,792
Total taxes on reserves (\$)*	3,901	2,888	6,559	10,679	10,777

All numbers from company 10K reports

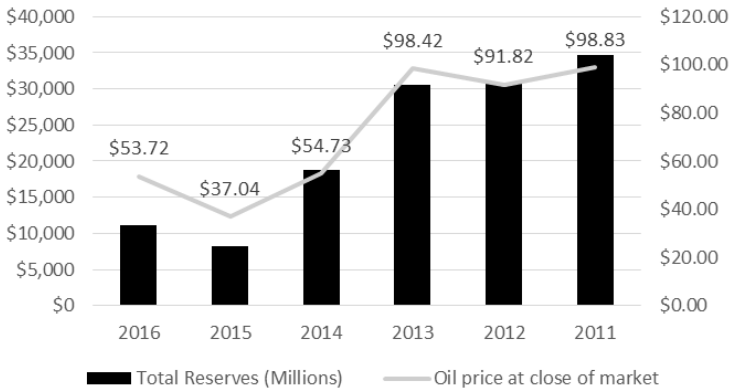


Figure 4: LIFO reserves (left axis) and crude oil prices (right axis).

Figure 4 shows the apparent relationship between oil prices and LIFO reserves for these three oil companies. As mentioned, the LIFO reserve is the difference between the value of inventory using FIFO and the value of inventory using LIFO. It appears from Figure 4 that LIFO reserve is directly affected by oil prices. However, more analysis is needed to determine true correlation as other factors, such as the quantity of the inventory, will also impact the LIFO reserve.

The volatility of oil prices gives the management of oil and gas companies an opportunity to mitigate the impact of a possible LIFO repeal. The change from LIFO to FIFO inventory during times of lower oil prices would result in significantly decreased tax liabilities than in periods of higher oil prices. Management could, during these periods of decreased oil prices, forecast the impact of a voluntary reduction in LIFO inventory. Oddly enough, depending on the prices of the various LIFO levels, a reduction in LIFO inventory could also lead to a reduction in net income and taxes. In a period of *decreasing* inventory costs, using LIFO matches the lowest, current costs against the revenues. By dipping into older inventory, the higher, older costs are matched against revenues, thus decreasing net income and the related tax liability.

Although oil and gas is the largest industry using LIFO, there are many industries and companies within industries that use LIFO. The major industries using LIFO are often manufacturing focused including chemical, food, metal, plastics, leather, and furniture (Frankel & Hsu, 2015). Pharmaceutical companies use LIFO as does the largest grocery-focused retailer in the U.S., Kroger (The Kroger Company, 2016). Ad-

ditionally, retail giants Wal-Mart (Wal-Mart Annual Report 2017) and Costco (Costco Annual Report 2016) value inventory using LIFO. With the beginning and ending of the supply chain using LIFO, whether a company uses LIFO itself or not, they are likely impacted.

Regardless of industry, any company using LIFO could benefit from understanding the relationship between current inventory cost and LIFO reserves as has been discussed using oil and gas data. By closely monitoring inventory costs and purposely timing decreases in inventory, management could minimize the tax liability impact of these voluntary reductions in inventory.

Conclusion

Flourishing in the boom-and-bust roots of the early 20th century, LIFO functioned as an impetus of economic growth for hundreds of firms across decades, but the political will to maintain the LIFO conformity rule rests on the whims of a politically transitory Congress and Executive branch, while the cultural paradigm shift during the late 20th and early 21st centuries regarding both corporate America generally and the oil and gas industry specifically have moved the previous stability of LIFO into an uncertain milieu. Prudent corporate governance would suggest exploring whatever various options are available to protect assets against temblors in this deeply important accounting principle.

Most of the options for mitigating the impact of a LIFO repeal rely on actions by the U.S. government or the accounting profession. For these options, it would be in the best interest of LIFO-using company management to actively expend resources to lobby various levels of the government and accounting profession. Conversely, there are options completely within the control of company management, such as the option to gain an understanding of, and monitor, inventory costs, which would result in voluntary reductions in LIFO reserves when it is most beneficial. However, any management decision to reduce LIFO reserves and thus reduce tax liability should not be made in isolation. Other factors, such as impact on key metrics, cash flow, or investor relations should also be considered.

References

Base Stock Inventories and Federal Income Taxation. (June 1936). *Harvard Business Review*, Vol. 51, 1430-1442.

Chatfield, M. and Vangermeersch, R. (1996). *The History of*

Accounting (RLE Accounting): An International Encyclopedia. Abingdon, UK: Routledge.

Congressional Budget Office. (2015). *Options for Reducing the Deficit.* Washington, D.C.: United States Congressional Budget Office.

Costco Wholesale Corporation. (2016). *Costco Annual Report.* Issaquah, Washington.

Crude Oil Price History. Retrieved March 17, 2017 from <http://www.fedprimerate.com/crude-oil-price-history.htm>

Davis, H. Z. (1982). History of LIFO. *Accounting Historials Journal Vol. 9, No. 1*, 1-23.

Frankel, M., & Hsu, P.-H. (2015). LIFO adoption by industry. *Journal of Accounting and Finance, Vol. 15, No. 5*, 42-53.

Krauss, C. (2007, February 2). *Exxon and Shell Report Record Profits for 2006.* Retrieved August 19, 2017 from The New York Times: <http://www.nytimes.com/2007/02/02/business/02oil.html>.

The Kroger Company. (2016). *Kroger Annual Report.* Cincinnati, Ohio.

Leone, M. (2010, July 15). *Sucking the LIFO Out of Inventory.* Retrieved August 19, 2017 from <http://ww2.cfo.com/accounting-tax/2010/07/sucking-the-lifo-out-of-inventory/>

Securities and Exchange Commission. (2008). *Roadmap for the Potential Use of Financial Statements Prepared in Accordance with IFRS by U.S. Issuers.* Washington D.C.: Securities and Exchange Commission.

Securities and Exchange Commission. (2012). *Work Plan for the Consideration of Incorporating IFRS into the Financial Reporting System for U.S. Issuers.* Washington D.C.: Securities and Exchange Commission.

Inside Gov. (2016). *2016 United States Budget.* Retrieved August 18, 2017 from <http://federal-budget.insidegov.com/l/119/2016#Overview&s=2WS4y3>

Wal-Mart Stores, Inc. (2016). *Wal-Mart Annual Report*. Bentonville, Arkansas.

Warshow, H. (1924). Inventory valuation and the business cycle. *Harvard Business Review*, Vol. 3, 27-34.

The White House. *Office of Management and Budget*. Retrieved August 19, 2017 from The White House, President Donald J. Trump: <https://www.whitehouse.gov/omb/budget/Historicals>.

Extracurricular Engagement and Person–Organization Fit through Internalizing Organizational Mission Statements and Values

Ryan Stephenson, Colt Rothlisberger, and Jonathan Westover

Utah Valley University

Abstract

Although there is great reason to believe that extracurricular organizations are of great benefit to college students across the country, little research has been conducted that measures how well students align with those organizations' values and, in turn, if those values affect the students' level of satisfaction and overall engagement within the organization. In our research, we analyzed a leadership program at an intermountain regional teaching university to find how the program's mission statement influenced the student's value alignment, engagement, and overall satisfaction during their participation in the program. We administered an online survey that used questions adapted from the Short Schwartz Values Survey and the Gallup Q12 surveys. From the results of our research, we concluded

that students who are satisfied, reflected on the mission statement, had opportunities to learn and grow, and aligned with the organization in benevolence and power were more likely to have a higher level of engagement.

Introduction

Each year college students across the United States enroll in extracurricular programs and societies. These organizations, designed to maximize student engagement, have been found to increase the probability of students being accepted into graduate schools and internships (Ferguson et al., 2002; Kuh et al., 2008). Scholars have found that when members of an organization actively reflect on the organization's mission statement, the mission statement becomes more impactful on the individuals in the organization. In any organization, value congruence between an individual and an organization leads to several positive outcomes (Griepentrog et al., 2012; Hoffman & Woehr, 2006; Kristof-Brown et al., 2005; Lauver & Kristof-Brown, 2001; Mowday et al., 1979; O'Reilly et al., 1991; Swider et al., 2015; Tsai et al., 2012; Yueran et al., 2016). For many college students, getting involved in extracurricular activities contributes to their success in developing their skills and gaining necessary experience for being competitive in the job market or being admitted into graduate programs following graduation (Ferguson et al., 2002; Kuh et al., 2008). Even though many students across campus currently get involved in these extracurricular activities, preliminary evidence suggests that many students' current level of engagement is not sufficient to drive the overall success of their extracurricular programs or their individual benefits following graduation, because their values have an incongruent alignment with the values of the organization (Krause & Coates, 2008; Kuh et al., 2008; Schertzer & Schertzer, 2004).

The authors of this paper analyzed student volunteer engagement and person-organization fit in an extracurricular student leadership program at an intermountain regional teaching university. We examined to what extent a student's understanding and internalization of the program mission statement influences his or her long-term engagement in the program. We analyzed whether or not each student has values congruence with the program by measuring how the student's values align with the organization's values. Online surveys were administered to students, with various questions exploring the relationship between students' engagement and their knowledge and internalization of the program mission statement and the influence of that internalization on

the depth and breadth of their overall engagement in the program. We hypothesize that the students who better understand the purpose of the program for themselves personally and for the organization as a whole will be more engaged throughout their experience in the leadership program. We also hypothesize that those students whose values are congruent with the organization's will be more engaged and satisfied with their experience in the leadership program.

Mission Statements

Over the past decade, mission statements have become an increasingly popular management tool, ranking among the top 10 management tools according to the annual Bain and Company business executive survey (Bain & Company, 2013). Along with the rise in popularity of mission statements, there has been copious research evaluating their effectiveness in organizational development and change management. Many scholars have found them to be an effective strategic tool in improving organizational performance and instilling values and purpose in members of various organizations around the world (Macedo et al., 2016; Patel et al., 2015).

Employee Engagement

In the past several years, employee engagement has been associated as a construct related to improving organizational performance (Gruman & Saks, 2011; Kumar and Pansari, 2016). Employee engagement has been defined as, "The individual's involvement and satisfaction with as well as enthusiasm for work" (Harter et al. 2002, 269). Employee engagement has also been defined as "an individual employee's cognitive, emotional, and behavioral state directed toward desired organizational outcomes" (Shuck & Wollard 2010, 15). These two definitions underscore employee engagement as a construct that primarily measures employees' attitudes and behaviors that are directed toward achieving organizational objectives. Highly engaged employees display attitudes and behaviors that directly correlate to improved organizational performance; some of these attitudes and behaviors are adaptability, creativity, proactivity, and productivity (Gruman & Saks, 2011). Overall, having engaged employees can, "help your organization achieve its mission, execute its strategy and generate important business results" (Vance 2006, 28).

Person–Organization Fit

A well-established topic of business research, person–organization fit, continues to be an important consideration for organizations (Arthur et al., 2006; Judge & Ferris, 1992; Kim et al., 2013; Yueran et al., 2016). Effective, successful leaders care about person–organization fit because they want to have the best people for their organization (Pfeffer, 1998; Schneider, 1987). Knowing how well a person does or will fit with an organization can predict overall job performance (Hoffman & Woehr, 2006; Tsai et al., 2012) and future job choices for job applicants (Griepentrog et al., 2012; Swider et al., 2015). Additionally, fit can help a company predict if an employee is likely to leave their position (Kristof-Brown et al., 2015; Lauver & Kristof-Brown, 2001; Mowday et al., 1979; O’Reilly et al., 1991; Yueran et al., 2016) and tell how satisfied an employee is in their position (Kristof-Brown et al., 2005; Lauver & Kristof-Brown, 2001, Mostafa & Gould-Williams, 2014; O’Reilly et al., 1991;). This indicates a level of commitment to the organization (Kristof-Brown et al., 2005; O’Reilly et al., 1991; Tsai et al., 2012).

Other related topics to person–organization fit include person–environment fit, person–job fit, and person–vocation fit (Kristof, 1996). While these constructs hold unique measurement differences, they often produce similar results. For example, according to Lauver & Kristof-Brown (2001), both person–job and person–organization fit impact job satisfaction and intention to quit. However, they are different in that high levels of person–organization fit provides that an individual can have more mobility within an organization and still fit well, while person–job fit does not have any relation to an individual’s fit once moved to a new position in the same company (Kristof, 1996). Additionally, with person–supervisor fit, an individual may have greater job satisfaction with a job because of a supervisor, but have no more likelihood to remain with the organization (Meglino et al., 1989).

Our Hypothesis

In essence, mission statements have been shown to be an effective tool for aligning personal, individual values with organizational values. These individual values can be measured in relation to the organization with person–organization fit. Person–organization shows us the values congruence between individuals and organizations. Values congruence can be indicative of higher satisfaction. All of these elements will lead to higher engagement from individuals within the organization. This is our ultimate goal: to discover how these values congruence and satis-

faction relate to and increase engagement within individuals in an organization.



Figure 1: Putting it all together

Literature Review

Person–Organization Fit

There are two types of person–organization fit, as related to attraction and job choice among adults: complementary fit and supplementary fit (DeClercq et al., 2008; Kristof, 1996; Piasentin & Chapman, 2006). Supplementary fit looks at what desirable values an individual and an organization have in common, so they supplement or increase those values (Guan et al.; 2011; Kristof, 1996; Piasentin & Chapman, 2006). By contrast, complementary fit refers to element(s) one has that the other does not have but needs (Guan et al., 2011; Piasentin & Chapman, 2006). Functionally, there are multiple ways of assessing and measuring person–organization fit related to complementary and supplementary fit.

Occasionally, goal congruence is used to measure person–organization fit (Piasentin & Chapman, 2006). Most commonly though, values congruence is used to measure fit between an individual and an organization (Meglino et al., 1989; Verquer et al., 2003; Vveinhardt et al., 2016). These are two measures that are good for both the individual and the organization to have in common.

Needs–supplies is a measure that is on the side of complementary fit, which describes the elements that an individual has that an organization does not have and needs, and likewise the elements that an organization has that the individual lacks and needs (Kristof, 1996; Piasentin & Chapman, 2006). Lastly, organizational personality is a

consideration that is a marriage of both complementary and supplementary fit, where, ideally, “*optimum* P-O fit may be achieved when each entity’s needs are fulfilled by the other *and* they share similar fundamental characteristics” (Kristof, 1996, p. 6).

Value Congruence

Value congruence between an individual and an organization leads to many positive outcomes. Among the positive outcomes, “value congruence significantly predicted satisfaction beyond personality and work environment congruence” (Verquer et al., 2003, 485). In students, Sorthaix & Lonnqvist (2015) found that value congruence between the individual and the organization had a positive relationship with life satisfaction and positive affect and a negative relationship with negative affect. Using the Schwartz value survey, Sorthaix & Lonnqvist (2015) measured value congruence by comparing individual’s scores to the average values scores of their population. Value congruence also strengthens organizational commitment the longer an individual is with an organization (Meglino et al., 1989). However, Natarajan & Nagar (2012) found that simply working at one organization does not mean that an individual will have value congruence with the organization over time. O’Reilly et al. (1991) found that when comparing an individual’s preferred culture to an organization’s culture, the closer they are, the higher the individual’s job satisfaction would be a year later. Additionally, the researchers found that when there was a larger difference between the individual’s preferences and the organization’s culture, this was indicative of turnover two years after the preferences were measured. The difference between an individual’s perception of the culture, or values, in the organization where they work and the individual’s ideal set of values and culture impacts task performance and what Goodman & Svyantek (1999) call contextual performance. In other words, the closer the culture of an organization is to an individual’s ideal culture, the more likely they are to perform extra tasks that benefit the organization, not just the minimum required to perform their duties.

Determine Fit

The growing body of academic research surrounding person–organization fit and value congruence raises the question: How can you determine which individuals have the same values as the company? Cable & Judge (1997) found that interviewers are often accurate in gauging the level of value congruence between an applicant and the organization for which they are interviewing. Additionally, often sub-

jective measures of value congruence by recruiters are more effective at determining future job satisfaction and organizational commitment than are objective value congruence measures (Verquer et al., 2013). Griepentrog et al. (2011) also found value in measuring fit during the recruitment period. These researchers claimed that the more individuals identified with an organization, the more likely they were to continue to pursue that organization three months later for employment.

Internalizing the mission statement to increase employee engagement

It can be argued that one of the main purposes of a mission statement is to inspire change in individuals and help the individuals adopt the values of an organization as their own personal values (Bart et al., 2001; Wang, 2011). Furthermore, individuals who desire to adopt their organization's values as their own should reflect on and internalize the mission/mission statement of the organization (Marimon et al., 2015). When individuals' values are then aligned with the organization's values, they are likely to have a greater commitment to the organization. In turn, because of the increase individual commitment to the organization, the organization is likely to have an increase in its overall organizational performance outcomes (Macedo et al., 2016). In relation to employee engagement, mission statements that have been reflected on and internalized by the employee help increase organizational performance outcomes (Macedo et al., 2016; Marimon et al., 2015), and organizational performance outcomes have been found to likely have a direct relationship to employee engagement behaviors (Gruman & Saks, 2011; Kahn, 1990).

In essence, we suggest that mission statements can have an indirect relationship with fostering engagement in individuals (Figure 2).



Figure 2: The role of mission statements in fostering engagement

Methodology Introduction

The purpose of this project is to find and execute a simple, reliable method of measuring person–organization fit and how it relates to

individual engagement within an organization. As such, we studied Schwartz's value model and Schwartz's value measurement instruments and found research wherein researchers used them to measure person-organization fit. In addition to Schwartz's value model and value measurement instruments, we studied Gallup's Q12 engagement survey and found it to be an effective instrument for measuring individual engagement in an organization. Our intent is to show the relationships among mission statements, person-organization fit, and engagement by analyzing the survey data and tracking the relationship between these measurements. Data were collected from a specific student extracurricular leadership group, with an 80% response rate for the entire student group population.

Value and Fit Methodology

The Schwartz's value model (Schwartz 1992) is a research-validated model of values that was originally examined in 20 different countries. This research was put forth to discover the relationships among how individuals' values are affected by their experience, how their values affect their behavior and attitudes, and how culture and location alters values. The results of the study were consistent across all 20 countries. Researchers later found the value model to be valid across cultures and both the SVS (Schwartz's Value Survey) and the PVQ (Portrait Values Questionnaire) can reliably measure values within the Schwartz's value model framework (Schwartz et al. 2001). Later, Lindeman & Verkasalo (2005) measured the validity and reliability of the SSVS (Short Schwartz's Value Survey) compared with the SVS and the PVQ. They determined that the SSVS has both good validity and good reliability.

A simple instrument to administer, the SSVS has one question per value rather than three to nine questions per value as in the SVS. The SSVS, researchers found, resulted in scores that are strongly correlated with the SVS and PVQ. The value scores found using the SSVS showed demographic similarities as were found in SVS and PVQ, such as women are more likely to identify with universalism and benevolence, and right-wing party voting individuals were more likely to be associated positively with power, security, and achievement (Lindeman & Verkasalo, 2005, 177).

De Clercq et al. (2008) used Schwartz's value model of 10 core values to measure supplementary person-organization fit by analyzing 42 different value instruments to determine how the items contained in those instruments fit within the Schwartz value model. Of the 42 value instruments the researchers analyzed, which included 1,578 items,

92.5% of the items could be classified under one of the 10 items in Schwartz’s model. Experts judged each of the items to determine if they would fit within one of the 10 values in Schwartz’s value model. Two of the instruments measured had many of the noncategorized items, and researchers found that the items included on these instruments could be categorized into “materialism” and “goal-orientedness” (p. 291). Thus, DeClerq et al. (2008) offered an adapted version of the Schwartz’s value model that had 12 values rather than the original 10. However, there has not been sufficient evidence that there are any missing values from the original Schwartz’s value model (p. 296). Overall, authors found that Schwartz’s value model is an adequate

Table 1: Adapted Short Schwartz Value Survey¹	
Please, rate the importance of the following values as a life-guiding principle for you. Use the 8-point scale in which 0 indicates that the value is opposed to your principles, 1 indicates that the values is not important for you, 4 indicates that the values is important, and 8 indicates that the value is of supreme importance for you.	Please, rate your agreement with the following values statements as they apply to the leadership program. Use the 8-point scale in which 0 indicates that the value is opposed to your principles, 1 indicates that the values is not at all present in the program and 8 indicates that the value is extremely present in the program and emphasized to a great extent.
POWER	POWER
ACHIEVEMENT	ACHIEVEMENT
HEDONISM	HEDONISM
STIMULATION	STIMULATION
SELF-DIRECTION	SELF-DIRECTION
UNIVERSALISM	UNIVERSALISM
BENEVOLENCE	BENEVOLENCE
TRADITION	TRADITION
CONFORMITY	CONFORMITY
SECURITY	SECURITY
To what extent do you feel your personal values align with the values present and emphasized in the leadership program?	

method for measuring supplementary person–organization fit. Table 1 shows the adapted SVSS, based upon the Schwartz value model, for the purposes of measuring the differences in values between individuals and the organization.

Q12 Methodology

A portion of our survey was adapted from the Gallup Q12 survey, which focuses on measuring employee engagement by asking questions focused on 12 main themes: overall satisfaction, expectations, materials and equipment, opportunity to do what I do best, recognition for good work, someone at work cares about me, encourages my development, opinions count, mission/purpose, associates committed to quality, best friend, progress and learn and grow (see Harter et al., 2016). Our survey items were based on the Gallup Q12 because of its high credibility: “[Q12]’s reliability, convergent validity, and criterion-related validity have been extensively studied. It is an instrument validated through prior psychometric studies as well as practical considerations regarding its usefulness for managers in creating change in the workplace” (Harter et al., 2016, 10). Table 2 below shows how the 12 questions from the Q12 survey were adapted to apply directly to the leadership program participants, as to allow maximum understanding for participants during the survey completion.

1. I know what is expected of me in the LEAD program.	7. I feel that my opinion matters to those who are leaders in the LEAD program.
2. I have the necessary tools and materials to fulfill the LEAD program requirements.	8. The Mission/Purpose of the LEAD program makes me feel my participation is important.
3. In the LEAD program, I have the opportunity to do what I do best every day.	9. My fellow students are committed to doing quality work.
4. In the last month I have received recognition or praise for doing good work.	10. I have a best friend in the LEAD program.
5. My Team Lead/CAL Coordinator cares about me as a person.	11. In the last 4 months, someone has talked to me about my progress.
6. There is at least 1 individual in the LEAD program who encourages my development	12. In the last year I have had opportunities to learn and grow.

In addition to the adapted Q12 survey and the Short Schwartz Value Survey, we included three global indicators for each of the main study constructs: (1) engagement, (2) person–organization fit, and (3) satisfaction:

- Overall, how engaged do you feel in the leadership program? (1=Strongly Agree, 5=Strongly Disagree)
- To what extent do you feel your personal values align with the values present and emphasized in the leadership program? (1=no alignment, 5=perfect alignment)
- Overall, how satisfied are you in your work with the leadership program? (1=extremely satisfied, 7=extremely unsatisfied)

Additionally, the following 4 questions measured on a 5-point Likert scale were used to measure the level of student engagement in the LEAD program.

- I can recite the leadership program mission statement verbatim, word for word.
- I have reflected on the leadership program mission statement this year during my involvement in completing the leadership program requirements.
- I get excited and look forward to attending/completing leadership program events/activities.
- If I was offered a similar position in a different extracurricular organization with similar compensation (scholarships and/or benefits) I would choose to stay in the leadership program.

Finally, in our survey we also included independent variables that would help us measure various demographics of the extracurricular program such as: (1) the division which the student is a part of within the organization, (2) the student’s year in school, (3) the student’s gender, (4) the current student status of each participant, (5) and the student’s current work situation.

Results

Comparative Means of Main Study Variables¹

Table 3 shows the main study variable means by the student

¹ All quantitative analysis was performed using STATA.

Variable	Trad.	Wolverine Ambass.	Women Helping Women	I Am First	All
Engagement	1.88	2.52	2.00	1.60	2.29
Satisfaction	2.00	3.11	2.00	2.00	2.73
Values alignment	3.96	3.57	4.00	4.40	3.73
Reflect on CAL mission	2.85	3.88	4.00	3.40	3.59
Learn and grow	1.15	1.94	1.33	1.00	1.67
Benevolence difference	0.54	1.49	1.67	-0.60	1.14
Power difference	-0.96	-0.91	-1.33	-0.20	0.90
Would take similar pos.	1.85	3.00	1.33	1.80	2.59
Excited for CAL events	1.73	2.95	1.67	1.20	2.51
My participation is impor.	1.88	2.92	2.67	1.20	2.56

organization division. Of particular note is that those within the Wolverine Ambassador division experience significantly higher levels of engagement and satisfaction than those in the other divisions. However, they are also the most likely to leave the program and take a similar position in a different student organization if presented with the opportunity. Additionally, Table 4 shows a breakdown of study variable means by gender. Men in the program appear to be more engaged and satisfied than the females.

Variable	Male	Female	All
Engagement	2.56	2.12	2.29
Satisfaction	3.15	2.45	2.73
Values alignment	3.56	3.83	3.73
Reflect on CAL mission	3.85	3.42	3.59
Learn and grow	1.77	1.60	1.67
Benevolence difference	1.46	0.93	1.14
Power difference	-1.08	-0.78	0.90
Would take similar pos.	2.72	2.50	2.59
Excited for CAL events	2.69	2.38	2.51
My participation is important	2.77	2.42	2.56

Regression Results

Table 5 shows regression results for all adapted Q12 items when regressed on our global engagement variable. While the overall predictability of the model is fairly high (adjusted r-squared of 0.490), only 3 of the Q12 items are statistically significant in the model (opportunities to grow, opinion matters, and motivated to go above and beyond). Thus, for this sample of students in extra/cocurricular student leadership positions, the Q12 as a whole does not appear to be a good fit in terms of understanding student engagement in the program. However, as seen in Table 6, removing insignificant variables from the Q12 regression analysis produces a better-fit model for engagement

Table 5: Q12 Engagement OLS Regression Results	
Variable	Value
In the last semester, I had opportunities to learn & grow	0.306(0.098) ^{***}
In the last 4 months, someone has talked to me about my progress	-0.098(0.091)
I have a best friend in the LEAD program.	0.040(0.056)
My fellow students are committed to doing quality work.	-0.032(0.073)
I feel that my opinion matters to those who are leaders in the LEAD program.	0.166(0.079) ^{**}
There is at least 1 individual in the LEAD program who encourages my development.	-0.101(0.128)
My Team Lead/CAL Coordinator cares about me as a person.	0.088(0.090)
In the last month I have received recognition or praise for doing good work.	-0.060(0.071)
In the LEAD program, I have the opportunity to do what I do best every day.	0.085(0.089)
I have the necessary tools and resources to fulfill the LEAD program requirements.	0.121(0.107)
I am motivated to go above and beyond what is expected of me as a member of the LEAD program.	0.253(0.087) ^{***}
I know what is expected of me in the LEAD program.	0.016(0.105)
N	99
Adjusted R-square	0.490
F	8.84 ^{****}

Coefficient values, followed by standard error values in parentheses.
 Level of significance: *p<.10; **p<.05; ***p<.01; ****p<.001.

Table 6: Refined Q12 Engagement OLS Regression Results	
Variable	Value
In the last semester, I had the opportunities to learn & grow.	0.237(0.079) ^{***}
I feel that my opinion matters to those who are leaders in the LEAD program.	0.189(0.060) ^{***}
I am motivated to go above and beyond what is expected of me as a member of the LEAD program.	0.272(0.072) ^{****}
Gender	-0.278(0.144) ^{***}
N	99
Adjusted R-square	0.516
F	27.13 ^{****}

Coefficient values, followed by standard error values in parentheses.
Level of significance: *p<.10; **p<.05; ***p<.01; ****p<.001.

Table 7: Q12 Satisfaction OLS Regression Results	
Variable	Value
In the last semester, I had opportunities to learn & grow	0.214(0.141)
In the last 4 months, someone has talked to me about my progress	0.051(0.132)
I have a best friend in the LEAD program.	0.083(0.081)
My fellow students are committed to doing quality work.	0.099(0.105)
I feel that my opinion matters to those who are leaders in the LEAD program.	0.226(0.114) ^{**}
There is at least 1 individual in the LEAD program who encourages my development.	0.068(0.185)
My Team Lead/CAL Coordinator cares about me as a person.	0.074(0.130)
In the last month I have received recognition or praise for doing good work.	0.093(0.103)
In the LEAD program, I have the opportunity to do what I do best every day.	0.214(0.129) [*]
I have the necessary tools and resources to fulfill the LEAD program requirements.	0.039(0.154)
I am motivated to go above and beyond what is expected of me as a member of the LEAD program.	0.382(0.126) ^{***}
I know what is expected of me in the LEAD program.	0.056(0.151)

Coefficient values, followed by standard error values in parentheses.
Level of significance: *p<.10; **p<.05; ***p<.01; ****p<.001.

within this context. Additionally, in this refined model, gender plays a significant role and overall predictability of the model improves by nearly 3% (adjusted r-squared is 0.516).

Finally, Table 7 shows regression results for all adapted Q12 items when regressed on our global satisfaction variable. Of note is that the overall predictability of the model is even higher than when using the global engagement variable (adjusted r-squared of 0.601). Additionally, only 3 of the Q12 items are statistically significant in the model (opinion matters, do what I do best, and motivated to go above and beyond). Thus, for this sample of students in extra/cocurricular student leadership positions, the Q12 as a whole does not appear to be a good fit in terms of understanding student satisfaction in the program, though it better predicts satisfaction than it does actual engagement. However, as seen in Table 8, removing insignificant variables from the Q12 regression analysis produces a better-fit model for satisfaction within this context. Additionally, in this refined model, both opportunities for growth and gender play a significant role and overall predictability of the model improves by more than 2% (adjusted r-squared is 0.622).

Variable	Value
In the last semester, I had the opportunities to learn & grow.	0.272(0.114)**
I feel that my opinion matters to those who are leaders in the LEAD program.	0.366(0.091)****
In the LEAD Program, I have the opportunity to do what I do best every day.	0.221(0.122)*
I am motivated to go above and beyond what is expected of me as a member of the LEAD program.	0.389(0.117)****
Gender	-0.385(0.208)*
N	99
Adjusted R-square	0.622
F	33.18****

Coefficient values, followed by standard error values in parentheses.
 Level of significance: * p<.10; ** p<.05; *** p<.01; **** p<.001.

Table 9 shows regression results for person–organization fit and value congruence (taking the difference between perceived personal values and organizational values using the adapted Short Schwartz items) when regressed on our global engagement variable. While the overall predictability of the model is fairly high (adjusted r-squared of

Variable	Value
Power value alignment	0.053(0.031)*
Achievement value alignment	-0.020(0.039)
Hedonism value alignment	-0.030(0.038)
Stimulation value alignment	-0.047(0.037)
Self-direction value alignment	-0.041(0.041)
Universalism value alignment	-0.027(0.033)
Benevolence value alignment	-0.153(0.036)****
Tradition value alignment	0.043(0.039)
Conformity value alignment	0.033(0.031)
Security value alignment	-0.033(0.035)
N	99
Adjusted R-square	0.429
F	8.35****

Coefficient values, followed by standard error values in parentheses.

Level of significance: * p<.10; ** p<.05; *** p<.01; **** p<.001.

0.429), only 2 of the SVSS items difference scores are statistically significant in the model (power value alignment and benevolence value alignment). Thus, for this sample of students in extra/cocurricular student leadership positions, using the SVSS items to measure person-organization fit only has modest applicability in understanding student engagement in the program. However, as seen in Table 10, removing insignificant variables from the regression analysis produces a better-fit model for engagement within this context. Additionally, in this refined model, both stimulation value alignment and gender plays a significant role.

Table 11 shows our combined model (adding elements from the Q12, the SVSS, as well as other survey variables) to understand what impacts student engagement. In this model, student overall satisfaction

Variable	Value
Power value alignment	0.054(0.029)*
Stimulation value alignment	-0.101(0.031)**
Benevolence value alignment	-0.164(0.031)****
N	99
Adjusted R-square	0.414
F	24.11****

Coefficient values, followed by standard error values in parentheses.

Level of significance: * p<.10; ** p<.05; *** p<.01; **** p<.001.

with the program, their reflection on the program mission, opportunities to grow within the program, benevolence value alignment, and power value alignment are the elements that significantly impact student engagement.

Variable	Value
Student satisfaction	0.324(0.052) ^{****}
Reflect on CAL mission	0.160(0.054) ^{***}
In the last semester, I had opportunities to learn & grow	0.165(0.074) ^{**}
Benevolence value alignment	0.067(0.030) ^{**}
Power value alignment	0.070(0.028) ^{**}
N	99
Adjusted R-square	0.612
F	31.90 ^{****}

Coefficient values, followed by standard error values in parentheses.
 Level of significance: *p<.10; **p<.05; ***p<.01; ****p<.001.

Finally, although separate from the main research question posed in this paper, we also asked students how likely they would be to take another position and leave this program. As retention is a very salient issue for all organizations, we decided to look at the factors impacting student retention. Table 12 shows regression results student retention. In this model, student satisfaction, excitement for program events and activities, a feeling of importance in participation, and power value alignment all were significant and collectively explain 54% of the variability in students’ stated likelihood to leave the program.

Variable	Value
Student satisfaction	0.161(0.083) [*]
I get excited and look forward to attending/completing CAL events/activities.	0.324(0.098) ^{***}
The Mission/Purpose of the LEAD program makes me feel my participation is importan.	0.292(0.098) ^{***}
Power value alignment	-0.067(0.040) [*]
N	99
Adjusted R-square	0.541
F	29.85 ^{****}

Coefficient values, followed by standard error values in parentheses.
 Level of significance: *p<.10; **p<.05; ***p<.01; ****p<.001.

Conclusions and Implications

Implications of the Literature

Ultimately, despite the extensive literature (academic and professional) utilizing the Q12 instrument, as a whole, the Q12 is an only marginally good fit for measuring satisfaction and engagement in this extracurricular student leadership organization. However, removing all but the significant variables increases the adjusted R-square and shows a stronger fit for measuring both satisfaction and engagement. Similarly, the SSVS, as a whole, is only a marginally good fit for measuring individual's' perception of person-organization fit and for helping to understand engagement in this extracurricular student leadership organization. Like the Q12, removing variables that are not significant results in a larger adjusted R-square and a stronger predictor of fit.

When combining select elements of both the Q12 and the SSVS, a more robust model can be created for measuring engagement in this extracurricular student leadership organization. A few other alterations can also be used to find a more indicative model of retention in the organization.

Implications Specific to the Leadership Program

Because of the lack of students who know the mission statement and/or have reflected on it in the past year, we highly recommend that training is conducted to emphasize what the mission of the leadership program is and how it relates to the student's overall performance. With a greater emphasis on organizational values, students will be more able to identify with the mission of the organization personally, which will lead to greater organizational outcomes and performance within the leadership program. Additional recommendations based on findings include:

Students vary on their views of having the opportunity to do what they do best every day in the leadership program.

These data lead us to consider that the leadership program could clarify its objectives and illustrate how each member's strengths will help to obtain those objectives.

There are varying levels of trust regarding giving feedback to leadership program administrators. We suggest implementing strategies to solicit more regular feedback from the students.

While about one-fifth of respondents were extremely satisfied with their work with the leadership program, nearly one-

half are moderately satisfied (44%). The last 36% are less than moderately satisfied or dissatisfied with their work in the leadership program. This should be reviewed by administrators of the program.

Nearly 90% strongly or somewhat agree that someone has checked on their progress in the last four months. This is good, and a source of strength in the leadership program.

Two-thirds of respondents rated the similarity between their own values and that of the leadership program as either a 4 or 5 out of five on a 1 (no alignment) to 5 (perfect alignment) Likert scale.

Discussion

While our results do not completely support the original hypothesis, the results do show that those who reflected on the mission statement were more likely to have higher values congruence with the organization in select values. With a population size of 124 and a response rate of 79.8%, there were 99 participants that completed the survey. Despite a small sample size, we discovered several statistically significant relationships. Individually, whether individuals have reflected on the mission statement has a statistically significant relationship with both satisfaction and engagement.

One of the reasons this leadership organization was selected was that it has a mission statement that clearly explained its values. The fact that few members of the organization reported having reflected on the mission statement was surprising. Even with a small population size, whether or not a student or member has reflected on the mission statement has a statistically significant impact on values congruence, satisfaction, and engagement in the organization.

Limitations and Future Research

One of the largest limitations to this research is that our sample size was relatively small and from only one organization on campus. To have a more broad generalization of the overall satisfaction and engagement levels of students in extracurricular programs, we suggest that future research include several different campus organizations at various universities. Increased sample size will also help in ascertaining the reliability and validity of the study variables and relations in our analysis.

Additionally, the data that were collected only reflect a snapshot of the overall engagement and satisfaction of the students. We suggest that future research include a longitudinal design from the same organi-

zations to provide a clearer representation of the overall engagement and satisfaction of students in extracurricular organizations, over time.

Finally, because of the small population size, future scholars should consider sampling multiple student organizations to have more generalizable results regarding student extracurricular involvement and how it is influenced by the organization's mission statement.

References

- Arthur, W. J., Bell, S. T., Villado, A. J., Doverspike, D. (2006) The use of person–organization fit in employment decision making: An assessment of its criterion-related validity. *J Appl Psychol*, 91(4), 786-801. Doi:10.1037/0021-9010.91.4.786.
- Bain & Company. (2013), “Top 10 management tools,” Insights: Management Tools and Trends, Bain & Company. Retrieved 2 Feb 2017 from www.bain.com/management_tools/BainTopTenTools/
- Bart, C.K., Bontis, N., Taggar, S. (2001). A model of the impact of mission statements on firm performance. *Manage Decis*, 39(1), 19-35.
- Cable, D. M., Judge, T. A. (1997). Interviewers' perceptions of person–organization fit and organizational selection decisions. *J Appl Psychol*, 82(4), 546-561. doi:10.1037/0021-9010.82.4.546
- De Clercq, S., Fontain, J. J., Anseel, F. (2008). In search of a comprehensive value model for assessing supplementary person–organization fit. *J Psychol*, 142(3), 277-302. doi:10.3200/JRLP.142.3.277-302
- Ferguson, E., James, D., Madeley, L. (2002). Factors associated with success in medical school: systematic review of the literature. *BMJ*, 324(7343), 952-957.
- Goodman, S. A., Svyantek, D. J. (1999). Person–organization fit and contextual performance: Do shared values matter. *J Vocat Behav*, 55(2), 254-275. doi:10.1006/jvbe.1998.1682
- Griepentrog, B. K., Harold, C. M., Holtz, B. C., Klimoski, R. J., Marsh, S. M. (2012). Integrating social identity and the theory of planned behavior: predicting withdrawal from an organizational recruitment process. *Pers Psychol*, 65(4), 723-753. doi:10.1111/peps.12000

Gruman, J. A., Saks, A. M. (2011). Performance management and employee engagement. *Hum Resour Manag Rev*, 21(2), 123-136.

Guan, Y., Deng, H., Risavy, S. D., Bond, M. H., Li, F. (2011). Supplementary fit, complementary fit, and work-related outcomes: The role of self-construal. *Appl Psychol* 60(2), 286-310. Doi:10.111/j.1464-0597.2010.00436.x

Harter, J. K., Schmidt, F. L., Hayes, T. L. (2002). Business-unit-level relationship between employee satisfaction, employee engagement, and business outcomes: A meta-analysis. *J Appl Psychol*, 87(2), 268-279. doi:10.1037//0021-9010.87.2.268

Harter, J. K., Schmidt, F. L., Agrawal, S., Plowman, S. K., Blue, A. (2016). The relationship between engagement at work and organizational outcomes. *Gallup*, 1-40.

Hoffman, B. J., Woehr, D. J. (2006). A quantitative review of the relationship between person–organization fit and behavioral outcomes. *J Vocat Behav*, 68(3), 389-399. Doi:10.1016/j.jvb.2005.08.003.

Judge, T. A., Ferris, G. R. (1992). The elusive criterion of fit in human resources staffing decisions. *Hum Resour Plann*, 15(4), 47-67.

Kahn, W. A. (1990). Psychological conditions of personal engagement and disengagement at work. *Acad Manage J*, 33, 692–724.

Kim, T., Aryee, S., Loi, R., Kim, S. (2013). Person–organization fit and employee outcomes: Test of a social exchange model. *Int J Hum Resour Manage*, 24(19), 3719-3737. Doi:10.1080/09585192.2013.781522

Krause, K. L., Coates, H. (2008). Students' engagement in first-year university. *Assess Eval Higher Ed*, 33(5), 493-505.

Kristof, A. L. (1996). Person–organization fit: An integrative review of its conceptualizations, measurement, and implications. *Pers Psychol*, 49(1), 1-49. doi:10.1111/j.1744-6570.1996.tb01790.x

Kristof-Brown, A. L., Zimmerman, R. D., Johnson, E. C. (2005). Consequences of individual's fit at work: A meta-analysis of person-job, person–organization, person-group, and person-supervisor fit. *Pers Psychol*, 58(2), 281-342. Doi:10.1111/j.1744-6570.2005.00672.x

Kuh, G. D., Cruce, T. M., Shoup, R., Kinzie, J., Gonyea, R. M. (2008). Unmasking the effects of student engagement on first-year college grades and persistence. *J Higher Ed*, 79(5), 540-563.

Kumar, V., Pansari, A. (2016). Competitive Advantage Through Engagement. *J Market Res*, 53(4), 497-514. doi:10.1509/jmr.15.0044

Lauver, K. J., Kristof-Brown, A. (2001). Distinguishing between employees' perceptions of person-job and person-organization fit. *J Vocat Behav*, 59(3), 454-470. Doi: 10.1006/jvbe.2001.1807.

Lindeman, M., Verkasalo, M. (2005). Measuring values with the Short Schwartz's Value Survey. *J Personality Assess*, 85(2), 170-178. Doi:10.1207/s15327752jpa8502_09

Macedo, I. M., Pinho, J. C., Silva, A. M. (2016). Revisiting the link between mission statements and organizational performance in the nonprofit sector: The mediating effect of organizational commitment. *Eur Manag J*, 34(1), 36-46. doi:10.1016/j.emj.2015.10.003

Meglino, B. M., Ravlin, E. C., Adkins, C. L. (1989). A work values approach to corporate culture: A field test of the value congruence process and its relationship to individual outcomes. *J Appl Psychol*, 74(3), 424-432. Doi:10.1037/0021-9010.74.3.424.

Mostafa, A. S., Gould-Williams, J. S. (2014). Testing the mediation effect of person-organization fit on the relationship between high performance HR practices and employee outcomes in the Egyptian public sector. *Int J Hum Resour Manage*, 25(2), 276-292. Doi:10.1080/09585192.2013.826917

Mowday, R. T., Steers, R. M., Porter, L. W. (1979). The measurement of organizational commitment. *J Vocat Behav*, 14(2), 224-247. Doi: 10.1016/0001-8791(79)90072-1.

Natarajan, N. K., Nagar, D. (2012). Effect of service tenure on value congruence—a case of public sector employees. *Indian J Industr Relat*, 47(4), 717-723.

O'Reilly III, C. A., Chatman, J., Caldwell, D. F. (1991). People and organizational culture: A profile comparison approach to assessing person-organization fit. *Acad Manage J*, 34(3), 487. doi:10.2307/256404

- Patel, B. S., Booker, L. D., Ramos, H. M., Bart, C. (2015). Mission statements and performance in non-profit organisations. *Corporate Governance: Int J Business Society*, 15(5), 759-774. doi:10.1108/cg-07-2015-0098
- Pfeffer, J. (1998). Seven practices of successful organizations. *Calif Manage Rev*, (2). 97-121. Doi:10.2307/41165935.
- Piasentin, K. A., Chapman, D. S. (2006). Subjective person–organization fit: Bridging the gap between conceptualization and measurement. *J Vocat Behav*, 69(2), 202-221. Doi:10.1016/j.jvb.2006.05.001
- Schertzer, C. B., Schertzer, S. M. (2004). Student satisfaction and retention: A conceptual model. *J Marketing Higher Ed*, 14(1), 79-91.
- Schneider, B. (1987). The people make the place. *Pers Psychol*, 40(3), 437-453. Doi:10.1111/j.1744-6570.1987.tb00609.x
- Schwartz, S. H. (1992). Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. *Adv Exp Soc Psychol*, 25(1), 1-65.
- Schwartz, S. H., Melech, G., Lehmann, A., Burgess, S., Harris, M., Owens, V. (2001). Extending the cross-cultural validity of the theory of basic human values with a different methods of measurement. *J Cross-Cultural Psychol*, 32(5), 519-542.
- Shuck, B., Wollard, K. (2010). Employee engagement & HRD: A seminal review of the foundations. *Hum Res Dev Rev* 9(1), 89–110.
- Sortheix, F. M., & Lonnqvist, J.-E. (2015). Person-group value congruence and subjective well-being in students from Argentina, Bulgaria and Finland: The role of interpersonal relationships. *Journal of Community and Applied Social Psychology*, 25, 34-48.
- Swider, B. W., Zimmerman, R. D., Barrick, M. R. (2015). Searching for the right fit: Development of applicant person–organization fit perceptions during the recruitment process. *J Appl Psychol*, 100(3), 880-893.

Tsai, W., Chen, H., Chen, C. (2012). Incremental validity of person–organization fit over the big five personality measures. *J Psychol*, 146(5), 485-509.

Vance, R. J. (2006). *Employee engagement and commitment: a guide to understanding, measuring and increasing engagement in your organization*. Alexandria, VA: SHRM Foundation.

Verquer, M. L., Beehr, T. A., Wagner, S. H. (2003). A meta-analysis of relations between person–organization fit and work attitudes. *J Vocat Behav*, 63, 473-489. doi:10.1016/S0001-8791(02)00036-2.

Vveinhardt, J., Gulbovaite, E., Streimikiene, D. (2016). Values congruence from the executives' viewpoint: value-based practices. *Econ Soc*, 9(2), 248-265. Doi:10.14254/2071-789X.2016/9-2/17.

Wang, Y. (2011). Mission-driven organizations in Japan: Management Philosophy and individual outcomes. *J Bus Ethics*, 101, 111-126.

Yueran, W., Fei, Z., Liu, L. (2016). Person–organization fit and turnover intention: professional identity as a moderator. *Soc Behav Pers*, 44(8), 1233-1242. Doi: 10.2224/sbp.2016.44.8.1233.

Appendix

Survey Instrument

Which division in the leadership program are you a part of?

- Traditional
- Wolverine Ambassador
- Women Helping Women
- I am First
- Army ROTC
- CELP (cultural envoy leadership program)

Rate the following from on scale from 1–5: 1=Strongly Agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Strongly Disagree

I can recite the leadership program mission statement verbatim, word for word.

I have reflected on the leadership program mission statement this year during my involvement in completing the leadership program requirements.

The leadership program Mission Statement inspires me
Completing the leadership program events and activities are a priority to me.

I get excited and look forward to attending/completing leadership program events/activities.

If I was offered a similar position in a different extra-curricular organization with similar compensation (scholarships and/or benefits) I would choose to stay in the leadership program.

I am motivated to go above and beyond of what is expected of me as a member of the leadership program.

I know what is expected of me in the leadership program.

I have the necessary tools and materials to fulfill the leadership program requirements.

In the leadership program, I have the opportunity to do what I do best every day.

In the last month I have received recognition or praise for doing good work.

My Team Lead/Leadership Program Coordinator cares about me as a person.

There is at least 1 individual in the leadership program who encourages my development

During program events I feel that my opinion matters.

The Mission/Purpose of the leadership program makes me feel my participation is important.

My fellow students are committed to doing quality work.

I have a best friend in the leadership program.

In the last 4 months, someone has talked to me about my progress.

In the last year I have had opportunities to learn and grow.

These survey questions were formulated and tailored to the needs of the leadership program from an employee engagement survey distributed by Gallup Poll.

Overall, how engaged do you feel in the leadership program? 1–5, 1=Strongly Agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Strongly Disagree

Personal Values

Please, rate the importance of the following values as a life-guiding principle for you. Use the 8-point scale in which 0 indicates

that the value is opposed to your principles, 1 indicates that the values is not important for you, 4 indicates that the values is important, and 8 indicates that the value is of supreme importance for you.

POWER (social power, authority, wealth)

- ACHIEVEMENT (success, capability, ambition, influence on people and events)
- HEDONISM (gratification of desires, enjoyment in life, self-indulgence)
- STIMULATION (daring, a varied and challenging life, an exciting life)
- SELF-DIRECTION (creativity, freedom, curiosity, independence, choosing one's own goals)
- UNIVERSALISM (broad-mindedness, beauty of nature and arts, social justice, a world at peace, equality, wisdom, unity with nature, environmental protection)
- BENEVOLENCE (helpfulness, honesty, forgiveness, loyalty, responsibility)
- TRADITION (respect for tradition, humbleness, accepting one's portion in life, devotion, modesty)
- CONFORMITY (obedience, honoring parents and elders, self-discipline, politeness)
- SECURITY (national security, family security, social order, cleanliness, reciprocation of favors)

Leadership Program Values

Please, rate your agreement with the following values statements as they apply to the leadership program. Use the 8-point scale in which 0 indicates that the value is opposed to your principles, 1 indicates that the values is not at all present in the program and 8 indicates that the value is extremely present in the program and emphasized to a great extent.

POWER (social power, authority, wealth) is an important value in the leadership program.

ACHIEVEMENT (success, capability, ambition, influence on people and events) is an important value in the leadership program.

HEDONISM (gratification of desires, enjoyment in life, self-indulgence) is an important value in the leadership program.

STIMULATION (daring, a varied and challenging life, an exciting life) is an important value in the leadership program.

SELF-DIRECTION (creativity, freedom, curiosity, independence, choosing one's own goals) is an important value in the leadership program.

UNIVERSALISM (broad-mindedness, beauty of nature and arts, social justice, a world at peace, equality, wisdom, unity with nature, environmental protection) is an important value in the leadership program.

BENEVOLENCE (helpfulness, honesty, forgiveness, loyalty, responsibility) is an important value in the leadership program.

TRADITION (respect for tradition, humbleness, accepting one's portion in life, devotion, modesty) is an important value in the leadership program.

CONFORMITY (obedience, honoring parents and elders, self-discipline, politeness) is an important value in the leadership program.

SECURITY (national security, family security, social order, cleanliness, reciprocation of favors) is an important value in the leadership program.

To what extent do you feel your personal values align with the values present and emphasized in the leadership program? (1–5 Likert Scale; 1=no alignment, 5=perfect alignment)

Overall, how satisfied are you in your work with the leadership program? (1–7 Likert scale; 1=extremely satisfied, 7=extremely unsatisfied)

Validating Prior-Learning Assessment Utilizing a Competency- Based Model

Jerry A. Van Os

Westminster College

Abstract

Prior-learning assessment (PLA) describes an assessment process in which students can earn college credit for college-level learning acquired outside a formal college curriculum. With PLA, students can progress more quickly towards degree completion, often at lower cost. PLA can be combined with a competency-based education curriculum to develop a “hybrid” approach that provides alternative pathways to degree completion for a significant population of nontraditional and transfer students with prior learning experience. To overcome concerns of academic rigor and quality associated with PLA, a uniform assessment process that measures student learning outcomes against predetermined competencies is critical. Direct assessment by faculty of submitted artifacts that demonstrate mastery of associated competencies through prior learning experiences is an essential component of PLA. A process to validate prior learning through direct assessment within a competency-based model is described in this

paper. To validate the PLA process for a competency-based approach, a pilot study utilizing 24 students who participated in a prior-learning process was reviewed. Pilot results indicated that, overall, assessment rubrics were sufficiently rigorous to assess program competencies associated with individual artifacts; however, some rubrics were not sufficiently rigorous to assess program competencies and program learning goals. This paper provides recommendations to improve the direct assessment process for prior learning.

Introduction

Higher education is facing several unique challenges: a changing student demographic in which students increasingly attend part-time, are employed, and require increased flexibility in meeting their educational objectives; a more expensive and unaffordable cost for large segments of potential students requiring new skills and knowledge to remain competitive and employable; and the need to allow transfer and adult degree-completion students to demonstrate college-level knowledge, skills, and competencies gained outside the classroom to accelerate their degree completion.

The current higher education model of classroom teaching in which grades are issued and credits earned needs to be reconsidered considering the challenges facing higher education today. The credit hour has become the de facto standard unit for measuring academic work and graduation completion in higher education. Under the current model, the credit hour links the awarding of academic credit to hours of contact between professors and students. The credit-hour standard, however, does not directly measure student learning. A recent study of the credit hour concludes that credit hours were never intended to measure learning, but because they are easy to measure and understand, they have become the basic building blocks in higher education for scheduling classes, determining faculty load, awarding financial aid, and meeting graduation requirements (Laitinen, 2012).

Over the last few decades, institutions of higher education have been increasingly concerned with finding ways to improve college affordability, accelerate degree completion, and more accurately measure student learning. Competency-based learning has been one response to these concerns. The distinguishing characteristic of competency-based education (CBE) is that it measures learning rather than “seat time.” Students’ progress is measured by demonstrating a competency, that is, “mastery” of the knowledge and skills required for meeting specific learning outcomes and program learning goals (PLGs). This can be

accomplished by decoupling “seat” time, tied to a credit-hours model, to demonstrating learning outcomes based on “mastery” of competencies.

A prior-learning process in institutions of higher education is another response to these concerns. It provides a way for diverse student populations to earn credits through previously completed coursework, examination, work, and military experience. By awarding credits for prior learning experiences, students can accelerate their degree completion and reduce overall tuition cost. Although many institutions of higher education have adopted different approaches to prior-learning assessment (PLA), students are able to progress more quickly towards degree completion at lower cost (Ryu, 2013).

This paper integrates two approaches, PLA and competency-based learning, to the challenges facing higher education. Specifically, it describes a process to validate prior learning through direct assessment within a competency-based model. Because of the large number of nontraditional students in higher education and the propensity of these students to bring learning experiences from various sources, many colleges and universities are beginning to offer alternative approaches to validating and credentialing college-level knowledge. Research results are promising, showing that adult students who earn credit for prior learning may in fact have better academic outcomes compared with their peers who do not earn such credit (Klein-Collins, 2010).

Assurance of Learning

Quality assurance in higher education has both theoretical and applied foundations based on total quality management and continuous improvement. The strategic implementation of the mission and vision of the institution and academic unit depends on measurable assurance of learning (AOL) outcomes. For business schools and programs, AOL, is a critical component in the accreditation process. To this end, business schools and programs must develop a set of PLGs; demonstrate a systematic AOL process that addresses PLGs and outcomes; and provide continuous improvement processes to improve program curriculum.

For example, in its revised standards, the Association to Advance Collegiate Business Schools of Business (AACSB, 2015) requires that Schools of Business utilize well-documented, systematic processes for determining and revising degree PLGs; designing, delivering, and improving degree program curricula to achieve learning goals; and demonstrating that degree PLGs have been met. AOL refers to processes

for demonstrating that students achieve learning expectations for the programs in which they participate and that schools demonstrate accountability to key stakeholders of the business unit. An effective AOL program should be able to (1) establish clear, measurable learning outcomes; (2) ensure that students have sufficient opportunities to achieve those outcomes; (3) systematically gather, analyze, and interpret evidence to determine how well student learning matches expectations; and (4) utilize assessment results to understand and improve student learning. It is up to schools to translate these general areas [curriculum content] into expected competencies consistent with the degree PLGs and students served. The areas that a curriculum should cover are not intended to be exhaustive but are purposely general in nature.

Evidence to support student learning and assessment in a competency-based model can take many forms, including the following definitions (Blackboard and American Council on Education, 2014):

Authentic Assessment: the assessment of competencies in a manner that as closely as possible approximates the way in which that competency will be demonstrated in the individual's professional and/or civic life.

Direct Assessment: the use of academic assessment methodologies for evidence-based evaluation of student competencies, rather than evaluation based on indirect measures such as the student's seat time in the classroom.

Formative Assessment: diagnostic in nature and refers to the use of assessment results by instructors or coaches to improve student performance

High-Stakes Assessment: the use of commercially produced, nationally normed tests to assess a student's competencies (e.g., ETS Major Field Test)

Indirect Assessment: the use of surveys, focus groups, or other formal methods to evaluate perceptions among a target group (e.g., students, graduates, alumni, employers)

Longitudinal Assessment: the assessment of the same variable or measure over long periods of time.

Mastery: the mechanism by which a student progresses through the education process to the desired end state

Personalized Learning: educational delivery in which individualized and differentiated practices are emphasized. Personalized learning offers students choices in their learning activities, ways of engaging with their peers and mentors, and other options that emphasize the importance of the "person" in educational contexts.

PLA: the evaluation and assessment of an individual's life learning

for college credit, certification, or advanced standing toward further education or training. PLA is often applied to military and work experience, as well as community service, informal online learning, and other learning acquired outside traditional academic institutions. PLA often uses evaluation of competency “mastery” to translate these learning experiences into college credits.

Project-Based Assessments: assignments that involve students in real-world experiences (or simulations of) in settings such as companies, not-for-profits, and community-based organizations. As such, the assessment of project-based assignments typically addresses competencies such as analytic thinking, quantitative reasoning, and teamwork skills, as well as disciplinary content.

Rubrics: assessment matrices with criteria for evaluating a competency and levels of demonstrated performance. Rubrics are applied to student work with the results used to determine levels of achievement.

Summative Assessment: judgmental in nature and refers to the use of assessment results by instructors or coaches to determine whether and how well a student achieved a learning objective or competency. In the context of program assessment, assessment results are used to determine the extent to which the program goals were achieved.

Competency-Based Education

There has been much discussion in the literature regarding competency-based learning models (Klein-Collins, 2013). Much of the discussion has centered on the need to change higher educational models to address critical issues associated with degree acceleration, academic quality, and academic rigor. A universal definition of CBE does not exist, and there is a variety of pedagogical approaches under the broad umbrella of the competency-based learning approach.

According to Blackboard and the American Council on Education (2014), there is no “one specific thing” called CBE. Klein-Collins (2013) notes that education models for CBE differ in important ways, however, several concepts and assumptions are common and collectively define CBE’s approach and purpose. These include the following common characteristics of a CBE:

- Competencies. An educated person is someone who does not just “know” but can also “do.”

- Quality. Defining the competencies required for graduation helps ensure the quality of graduation.
- Assessment. Competency-based assessment validates learning.
- Learning. Programs should focus on learning rather than on time spent in learning activities.

There is no single “right way” to do CBE, but there are two different ways to approach it, as defined by the Council of Regional Accrediting Commissions:

In a course/credit-based approach. The demonstration of competencies is embedded into a conventional curriculum comprising courses to be completed to earn credits toward a degree or credential. Students may accelerate their learning and receive credit for the course when they have demonstrated mastery of the competencies by passing a summative assessment.

Direct assessment. The direct assessment approach disregards conventional courses and bases both the evaluation of student achievement and the award of a degree or credential solely on the demonstration of competencies. Direct assessment programs allow students to proceed at their own pace rather than progress through courses offered in a traditional academic term.

AOL Challenges to Competency-Based Delivery Models

Although the goal of an effective AOL process should be inclusive to a variety of education paradigms and delivery models, the truth is that this is not always the case. The development of CBE programs and frameworks by a variety of institutions, public, private and for-profit have been promulgated, but many challenges continue to exist regarding the long-term viability of a CBE model. These include, but are not limited to the following (Ford, 2014):

The complexity associated with aligning not just teaching and learning, but also assessments and accountability reporting to multiple outcome-oriented competency frameworks and evolving standards, while simultaneously remaining faithful to the unique institutional mission and purpose.

The development of adaptable institutional infrastructures and operations, increasingly collaborative cultures and permeable boundaries that effectively welcome and encourage critical/appreciate inquiry, teamwork, transparency, internal and external stakeholder involvement, and transformation improvement.

Lack of agreement in the higher education sector on a single approach to the design or implementation of CBE programs.
Concerns by faculty about displacement or change in roles and status.

Institutions seeking national accreditation for their business programs also face unique challenges that impact CBE models within business schools. Accreditation requirements tend to focus on faculty qualifications and engagement, curriculum content, faculty resources, and admission standards. Although AACSB does not advocate a specific approach to meeting its standards and does not specifically recommend standardization, interpreting and complying with the standards may easily be a movement towards just that. Strong risk aversion towards not gaining accreditation leads to conservative and documentational interpretation of the standards and discourages and subordinates program innovation in the accreditation process. On this point, both critics of a competency-based learning approach and accreditation bodies will require a comprehensive assessment model that measures learning outcomes to overcome concerns of academic quality and rigor compared to more traditional educational delivery models (Kilpatrick et al., 2008).

Prior-Learning Assessment

PLA describes a process in which an educational institution can award college credit to a student based on prior educational, working, military or life experiences in which the student can demonstrate competency mastery of the topic or subject. The focus on learning rather than time spent in a classroom has created renewed interest in prior learning for college credit, including portfolio assessment, promulgated by the Council for Adult and Experiential Learning. Portfolio assessment of prior learning has the potential to significantly reduce the cost of education and accelerate degree completion for qualified learners that can document and demonstrate mastery of competencies. Students prepare a portfolio of their experiential learning, which is then assessed by faculty with appropriate subject matter expertise to determine whether a credit is awarded for “mastery” of an associated competency.

According to Klein-Collins (2013), competency-based programs share a common philosophy with PLA: that what individuals know is more important than where or how they acquired that knowledge. In addition, competency-based programs are a natural fit with many methods of PLA because they assess the outcomes of student learning in a rigorous way. Both CBE and PLA utilize a “direct” assessment approach.

Emerging competency-based degree programs are a result of changing student demographics; improved technology; online and adaptive learning experiences; open educational resources; learning management systems; and access to online coaching and advising. Built on underlying concepts of focusing on what students know and can do rather than accumulating credits and seat time experiences has created an interest in a competency-based approach as part of mainstream higher education. CBE has become a major topic of discussion in higher education as it becomes increasingly relevant as institutions search for ways to improve college affordability, accelerate degree completion, and more accurately measure student learning.

PLA supports the following value propositions for a competency-based approach to PLA, including:

Academic Quality. Credits for prior learning are evaluated by qualified faculty and assessed utilizing existing AOL methods that integrate competency-based mapping to PLGs and utilization of portfolios that demonstrate evidence of “mastery” of competencies.

Academic Rigor. Credits for prior learning will be evaluated for mastery of associated competencies based on established rubrics that assess the level of competency for program learning outcomes.

Academic Acceleration. Students can earn credits for prior learning experiences that can be applied to their degree completion at the undergraduate level. This will allow transfer and adult degree-completion students to demonstrate college-level knowledge, skills, and competencies gained outside the classroom and accelerate their degree completion.

A Prior-Learning Model Based on a Competency-Based Format

PLA and CBE should not be viewed as separate strategies or approaches to degree completion. Their relationship is close but needs to be understood in terms of their philosophical underpinnings, their shared approach to assessing learning outcomes, and their operational compatibility at the institutional level. Tate and Klein-Collins (2015) identified three areas of common intersection for PLA and CBE:

PLA and CBE, in all their various forms, share a common underlying philosophy that higher education needs to value and reward what a student knows and can do. With PLA, students earn college credit for what they have learned outside of the

institution. With CBE, students have the option to draw on their prior learning to demonstrate the competencies in the program through required assessments.

Both PLA and CBE best practice dictates that the assessment of learning uses a more uniform process and that the assessment processes used are criterion referenced, meaning that they measure student learning against predetermined criteria [rubrics] and not by a subjective process.

CBE programs can offer PLA as an integrated part of the program. PLA can be an important gateway to a CBE program, with several PLA methods offered to students so that they can demonstrate required competencies based on their prior experiential learning. This is typically called the “hybrid” approach to CBE, in which there is flexibility for students to earn credit. Students can bring transfer credit; credit from College-Level Examination Program exams; credit or competencies from portfolio assessment; and credit awarded for non-college training and credentials that “count” towards a competency-based degree.

A hybrid approach utilizes online adaptive learning competency modules, applied projects, open educational resources, or a combination of options and traditionally-delivered coursework. Hybrid options differ from the direct assessment form of CBE, which is currently offered by only a handful of institutions and tends to employ highly structured learning and assessment environments that do not allow for the flexibility of a hybrid approach.

An example of a hybrid approach to PLA, in a competency-based model, is utilized by one institution in their project-based Bachelor of Business Administration (BBA) program. The demonstration of competency-based learning is built on a foundation of interrelationships that begin with the identification of college-wide learning goals (CWLGs) and PLGs that support the strategic mission and vision of the institution and end with direct assessment of prior learning artifacts by a faculty coach to determine if “mastery” of the associated competency was achieved. Figure 1 illustrates a competency-based approach to PLA. In this prior learning model, the following definitions are utilized:

CWLGs: Observable and measurable statements about what the *institution* delivers and expects to see in each of its graduates.

PLGs: Observable and measurable statements about what a specific *program* delivers and expects see in each of its graduates.

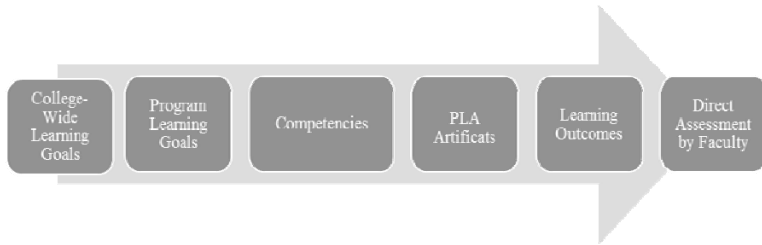


Figure 1: A prior learning model based on a competency-based format

Competencies: Predefined descriptions of applications or skills that the student learner must be able to do to demonstrate mastery.

PLA artifacts: Examples of prior learning activities, submitted as part of a portfolio that demonstrate mastery of an associated competency for credit towards a degree.

Learning outcomes: Measurable demonstration of learning of a competency, utilizing an established rubric, and assessed as part of a PLA portfolio submission for specific competencies.

Direct assessment: Assessment of a PLA artifact by a faculty coach to determine mastery of a competency utilizing an established rubric.

Prior-Learning Pilot Results for a Project-Based Curriculum

This paper summarizes the experience of an institution that currently has a PLA program approved by the Northwest Council of Colleges and Universities. Under the current model, students can receive up to 45 semester credits of approved prior learning, within established limits and guidelines, regarding transfer credits. For several years, the PLA program was discontinued and placed on academic hiatus because of faculty concerns about academic rigor and consistency of assessment.

In 2014, the institution completed a comprehensive strategic plan and identified as one of its strategic initiatives that the College provide programs, opportunities, and pathways for degree completion that meet the needs of a broader range of learners, as evidenced by:

- Serving a more diverse student body;

- Hosting dedicated alternative pathways featuring cohort and market driven programs with fiscal viability;

- Creating opportunities for students to demonstrate college-level knowledge, skills, and competencies gained outside the classroom;
- Awarding credit through PLA models, providing opportunities for students to engage in innovative contract majors to better tailor their education to their unique needs and goals; and
- Cultivating meaningful participation by students in gap-year and bridge sequence programs.

As a result, the project-based BBA program received administrative approval to develop a prior-learning model starting fall semester 2014. Based on the pilot results, continuation of the PLA program would be evaluated, and if successful, the PLA process could be expanded to other undergraduate programs in the future.

The Project-Based Competency Education Model

This paper describes how one institution utilizes a project-based approach to CBE. Their project-based curriculum is based on three value propositions whose intersection results in enhanced student learning. The project-based learning model is built on a framework of identifying competencies that support program learning outcomes; project assignments that demonstrate mastery of competencies; and faculty coaching to facilitate student performance in achieving mastery of competencies. As illustrated in Figure 2, when the value-propositions are aligned and focused, student learning is enhanced.



Figure 2: A project-based competency model

The project-based curriculum is structured around students demonstrating mastery of 60 competencies, allocated to five project sequences, consisting of six projects per sequence for a total of 12 credit hours per sequence. A sequence is designed to be completed by a student learner in approximately one semester, and each project assignment is equal to two credits of college credit towards their degree

completion for a BBA degree. A competency is worth one semester credit hour. Students matriculated in the BBA programs are required to have completed the equivalent of an Associate's of Arts or Science degree, in which they receive a total of 64 hours of credit. The total hours required for the BBA degree is 124 credit hours.

The reintroduction of prior learning to the project-based curriculum was based on meeting key strategic outcomes of the college-wide strategic plan to support alternative pathways for degree completion, acceleration of degree completion, and lowering the overall cost of tuition.

The PLA Process

In coordination with key institutional stakeholders, the following PLA process was developed and outlined as follows:

- A student applies for PLA to Graduate and Adult Program Services (GAPS), which provides staff support for competency-based programs. As part of the application, student candidates for PLA will have completed a self evaluation of their prior learning experiences relative to the BBA program competencies.
- The staff of the GAPS office will review the PLA portfolio application and determine if the student has sufficient prior learning experiences based on the application outlining prior academic, work, military, and life experience. If the PLA application is approved, the student is notified and given instructions regarding the requirements for submitting a PLA e-portfolio. Also, an approved PLA portfolio application will require a fee for further evaluation and review. If the application is not approved, the student will receive a letter from the GAPS office denying further PLA review based on insufficient qualifying prior learning experiences.
- For approved PLA portfolio applications, the GAPS office will send students documentation outlining the requirements and necessary artifacts to support a PLA portfolio submission. Students will be provided a list of approved competencies and rubrics used to evaluate “mastery” by project coaches. Students will be given examples of what constitutes an acceptable artifact for PLA consideration. Students will have one full semester to complete a PLA portfolio submission.
- Students will complete the requirements for the PLA portfolio and submit an electronic version within the learning management system (e.g., Canvas). Once the PLA portfolio is submit-

ted, the GAPS office will acknowledge receipt of the portfolio and assign a committee of three full-time faculty members to review the portfolio submission. Faculty composition of the PLA review committee will consist of two faculty from the home school (e.g., Business) and one faculty member representing a school outside of the program (e.g., Arts & Sciences). Each faculty member will have one week to review the PLA portfolio submission and make recommendations with respect to prior-learning credits awarded for each competency addressed in the portfolio. Each faculty member will receive a stipend upon completion of a comprehensive review of the PLA portfolio.

- Upon review of the PLA portfolio, GAPS will summarize the competencies approved by the faculty members. If two of the three faculty members approve a competency, the student will receive prior-learning credit for the competency. A summary of competencies approved and denied will be provided to the student learner.
- If the student feels that a competency was inappropriately denied based on the evidence provided, they can appeal to the GAPS office, with supporting materials, and have an opportunity to resubmit the portfolio for one additional review. If after a second review, a competency is still not approved, the PLA decision is final.
- Once a PLA portfolio is finally reviewed, a summary report is sent to the College Registrar by the GAPS office so that prior-learning credits can be posted to the student transcript. Each of the competencies will be mapped to a project in the undergraduate project-based programs.

PLA Pilot Results

A total of 24 students were selected to participate in the pilot for the 2014-15 academic year based on the PLA process previously described. Each student was required to complete a portfolio that included artifacts that demonstrated mastery of specific competencies. A summary of PLA results is summarized in Table 1.

Rubrics to evaluate learning outcomes for competencies were developed by the competency-based faculty. To provide for uniformity across all competencies, PLA evaluation rubrics were standardized to include five key learning outcomes from established project rubrics for project assignments. Both competencies and learning outcomes were developed utilizing Bloom's taxonomy for cognitive processes

	Fall 2014	Spring 2015	2014-15 Total
Students who requested prior-learning credit	9	15	24
Students who received prior-learning credit	7	13	20
Total number of credits applied for	191	138	329
Total number of credits awarded	90	130	220
Percentage credits awarded	47.6%	94.2%	66.9%
Mean number of credits awarded	12.9	10.0	11.0
Highest number of credits awarded	26	30	30
Lowest number of credits awarded	0	0	0

(Anderson, 2001). Each competency and learning outcome was based on a specific level of cognitive process. Bloom's taxonomy identifies six levels of cognitive process that build on each other: *remembering, understanding, applying, analyzing, evaluating, and creating*. One of the goals of creating competencies and learning outcomes was to span the full range of cognitive processes based on an iterative and graded process. In other words, as student learners progress through the project-based curriculum, competencies and associated learning outcomes would be assessed at higher levels of demonstrated learning.

Each competency is associated with a specific project sequence and PLG. Competencies for the BBA program were equally distributed to the 5 project sequences, with each sequence assigned a total of 12 competencies. A total of 7 PLGs are associated with the BBA program and assigned across the spectrum of project sequences and assignments. Table 2 summarizes PLA credits awarded for each project sequence during 2014-15.

One of the goals of the project-based curriculum is that students need to demonstrate mastery of each competency at the highest level of performance, as defined by the competency and learning outcomes, through an iterative, graded, and intentionally sequenced manner. As students' progress through the curriculum, competencies and associated learning outcomes are progressively assessed at higher levels of cognitive processes according to Bloom's revised taxonomy. This assumes that students applying for credit would be more successful in the earlier project sequences as compared with the later projects. The 2014-15 pilot results indicate that this pattern was validated, except for project sequence four in which PLA candidates showed an increase after the third project sequence. This raises some questions regarding the academic rigor and integrity of the prior-learning process.

Project Sequence	PLA Credits Applied For	PLA Credits Earned	Percent PLA Completed
Project Sequence 1: Professional Development	160	124	77.5
Project Sequence 2: Competitive Analysis	56	35	62.5
Project Sequence 3: Enterprise Performance	31	16	51.6
Project Sequence 4: Strategy and Leadership	53	32	60.4
Project Sequence 5: Business/Commercial Plan	29	13	44.8
Totals	329	220	66.9

One of the primary criticisms of PLA is the argument of academic rigor. Can students demonstrate understanding of learning outcomes associated with a competency based on prior learning experiences as opposed to “seat time” in a classroom environment? Many traditional faculty believe that PLA and traditional classroom learning are not equivalent. To overcome this argument and perception of academic rigor, one approach is a CBE model. Credits for prior learning will be evaluated for mastery of associated competencies based on established rubrics, developed by full-time faculty, that assess the level of competency for program learning outcomes. Overall validity of the rubric for assessing learning outcomes and program competencies is key to overcoming the academic rigor argument.

Validating PLA Outcomes

To address the issue of academic rigor associated with awarding college credits for prior learning experiences, the following questions will be addressed in this paper to assess the validity of rubrics to assess program competencies for academic credit:

- Are rubrics that assess learning outcomes sufficiently rigorous to assess program competencies?
- Are rubrics that assess learning outcomes sufficiently rigorous to assess program competencies associated with project sequences?
- Are rubrics that assess learning outcomes sufficiently rigorous to assess program competencies associated with PLGs?

To develop empirical data to assess the academic rigor of rubrics, Bloom's taxonomy for cognitive processes was utilized. Each program competency and learning outcome was assigned to one of the six levels of cognitive process: *remembering, understanding, applying, analyzing, evaluating, creating*. Each competency and learning outcome was assigned a value from 1 to 6, associated with one of the six levels of Bloom's taxonomy. The higher the level, the higher the value (e.g., remembering = 1, creating = 6).

The value of each competency was statistically related to the associated rubric value, based on the average value of the learning outcomes assigned to a rubric. Because learning outcomes and program competencies were intended to be both iterative and graded, the rubric comparison is critical for validating academic rigor. Using a t-statistic that was significant at the .95 or .99 confidence interval would invalidate the "null" hypothesis and indicate that the competency and associated rubric and learning outcomes were not aligned.

To address the first question, each competency in the project-related BBA program was compared to the associated rubric and learning outcomes. A total of 60 competencies (59 degrees of freedom) utilized in the BBA program were compared with the associated rubric. For PLA purposes, student learners can apply for prior-learning credit for each competency within the limitations of the PLA process and guidelines. Table 3 summarizes the comparison of competencies to associated rubrics for the pilot PLA process for 2014-15.

Table 3: Comparison of BBA Program Competencies to Associated Rubrics				
Program Competency Average	Rubric Average	N	Degrees of Freedom	t-Statistic
3.5	3.0	60	59	2.555*

*Significant at the .95 confidence level

A review of the results of the first research question comparing all program competency values and average rubric values was significant at the .95 confidence level indicating that the null hypothesis is not affirmed. This would indicate that one or more program competencies are evaluated by rubrics that do not assess learning outcomes at the required level of cognition per Bloom's taxonomy. Thus, further analysis is required to identify where program competencies and associated rubrics are nonaligned.

The second research question addressed program competency alignment with rubrics at the project sequence level. As previously indicated, program competencies are distributed evenly among the five

project sequences. Table 4 summarizes the comparison of competencies to associated rubrics for each project sequence.

Table 4: Comparison of BBA program competencies by project sequence to associated rubrics					
Project Sequence: Title	N (60)	Program Competency Average	Rubric Average	Degrees of Freedom	t-statistic
Sequence 1: Professional Development	12	3.1	3.2	11	-0.466
Sequence 2: Competitive Analysis	12	2.6	2.6	11	0.075
Sequence 3: Enterprise Performance	12	3.3	2.9	11	1.031
Sequence 4: Strategy and Leadership	12	3.9	3.2	11	2.096
Sequence 5: Business/ Commercial Plan	12	4.5	3.4	11	2.027

Results for the second research question indicate that program competencies assigned to project sequences and the associated rubrics were not significant at the .95 or .99 level, indicating that the null hypothesis is affirmed. This indicates that program competencies for individual project sequences are being evaluated by rubrics that assess learning outcomes at the required level of cognition per Bloom's taxonomy. Further analysis is required to determine where program competencies are not aligned with associated rubrics.

The final research question addresses program competency alignment with rubrics at the PLG level. As defined by the strategic vision and mission of the College, CWLGs and PLGs were defined for each program. For the project-based program, a total of 7 PLGs were identified. Each competency is aligned with a specific PLG. Table 5 summarizes the comparison of program competencies to associated rubrics for each PLG.

Table 5: Comparison of BBA Program Competencies by PLG to Associated Rubrics

Program Learning Goal	N (60)	Program Competency Average	Rubric Average	Degrees of Freedom	t-statistic
Communication skills	4	3.8	4.1	3	-0.397
Ethical decision making	2	2.0	3.0	1	N/A
Critical thinking	7	3.1	3.0	6	0.757
Leadership and collaboration	4	3.5	3.6	3	-0.080
Strategic perspective	16	3.9	3.2	15	3.016**
Organizational performance	19	3.4	2.7	18	2.503*
Market execution	8	3.1	2.6	7	1.150

*Significant at the .95 confidence level

**Significant at the .99 confidence level

Results for the third question indicate that program competencies assigned to PLGs and the associated rubrics were significant at both the .95 or .99 level, indicating that the null hypothesis is not affirmed. Significant differences between program learning competencies and evaluation rubrics were identified for strategic perspective and organizational performance. Because of a low number of occurrences, no t-statistic was calculated for ethical decision making. The PLGs identified as being significant represented over one-half of the occurrences for PLGs and spanned all five project sequences. Consistency in evaluating these PLGs require further analysis and recommendations to mitigate the effects on academic rigor and consistency.

Conclusions and Summary

In addressing concerns about the academic rigor associated with PLA, this paper defines academic rigor for prior-learning credit as demonstrating mastery of a specific competency based on an established rubric. Rubrics utilized for PLA were developed by full-time faculty and directly assessed by a qualified faculty coach to evaluate college credit for prior learning. Pilot results indicated that, generally, rubrics were sufficiently rigorous to assess program competencies associated within individual project sequences; however, some rubrics

were not sufficiently rigorous to assess program competencies associated with specific PLGs. Significant differences were identified for competencies associated with PLGs for strategic perspective and organizational performance. Table 6 illustrates an example of a rubric in which the level of the program competency as compared with the learning outcomes assessed by the rubric, as determined by Bloom's taxonomy, was significantly different. The pilot for 2014-15 identified several opportunities for improving the PLA process. The following were identified as areas for improvement:

- Reevaluate rubrics associated with assessing competencies for PLGs associated with strategic perspective and organizational performance.
- Assess program competencies for the fourth project sequence, competitive analysis, to ensure that competencies are assessed at higher levels of cognitive skills as students' progress through the BBA curriculum.
- Consider revising competencies so that there is better representation among all PLGs.
- Develop revised rubrics for competencies associated with strategic perspective and organizational performance to ensure alignment with the competency and learning outcomes based on Bloom's taxonomy for cognitive processes.
- Provide students with additional support before submitting their PLA portfolios. Many nontraditional students have limited experience writing academic papers and may not fully understand the academic quality standards typical in higher education.
- Provide more coaching and develop a suite of online resources to better acquaint students with the PLA process and expectations of PLA portfolios.
- Provide more training to the individual teaching the introductory PLA orientation.

After identifying rubrics in which the program competency differed significantly with the learning outcomes, as determined by the level of cognitive ability, several assessment rubrics were updated and revised. For example, Table 7 illustrates how key learning outcomes were revised to address higher levels of cognition by changing the level of cognitive processes under Bloom's taxonomy to be assessed at higher levels of demonstrated learning. Changes are bolded to represent higher levels of required cognitive learning.

Table 6: Balanced Scorecard Implementation (Previous)		
PLG: Organizational Performance		
Competency: Evaluate organizational performance using performance metrics, industry standards, and/or organizational goals.		
Learning Outcomes	Does Not Meet	Meets
Student must “meet” all the learning outcomes to demonstrate mastery of the competency.	Learner <i>does not</i> meet the learning outcomes outlined in the rubric. Further development is required.	Learner can demonstrate the requirements of the learning outcomes outlined.
<i>Discuss</i> how performance measures and metrics are utilized in the organization to support the vision and mission.	The artifact submission <i>does not</i> discuss how these support the mission and vision of the organization	The artifact submission discusses how these support the mission and vision of the organization.
<i>Describe</i> how performance measures are developed based on internal assessment or external benchmarks.	The artifact submission <i>does not</i> describe how these are developed.	The artifact submission describes how these are developed.
<i>Describe</i> how organizational performance is communicated within the organization.	The artifact submission <i>does not</i> describe communication to key stakeholders in the organization.	The artifact submission describes communication to key stakeholders of the organization.
<i>Evaluate</i> if performance measures for each perspective addresses value creation for shareholder’s customers, employees and strategic partners.	The artifact submission <i>does not</i> evaluate if performance measures create value.	The artifact submission evaluates performance measures based on the value.
<i>Submit</i> a document that demonstrates understanding and evidence of the competency and PLG.	Artifact submission is <i>not</i> in an appropriate format and/or does not address all the required learning outcomes.	Artifact submission is submitted in an appropriate format and includes the required learning outcomes described above.

Table 7: Balanced Scorecard Implementation (Revised)		
PLG: Organizational Performance		
Competency: <i>Evaluate</i> organizational performance using performance metrics, industry standards, and/or organizational goals.		
Learning Outcomes	Does Not Meet	Meets
Student must “meet” all the learning outcomes to demonstrate mastery of the competency.	Learner <i>does not</i> meet the learning outcomes outlined in the rubric. Further development is required.	Learner can demonstrate the requirements of the learning outcomes outlined in the rubric.
<i>Interpret</i> how performance measures and metrics are utilized in the organization to support the vision and mission.	The artifact submission <i>does not</i> interpret how these support the mission and vision of the organization.	The artifact submission interprets how these support the mission and vision of the organization.
<i>Provide</i> examples how performance measures are developed based on internal assessment or external benchmarks.	The artifact submission <i>does not</i> provide examples how these are developed.	The artifact submission provides examples how these are developed.
<i>Demonstrate</i> how organizational performance is communicated within the organization.	The artifact submission <i>does not</i> demonstrate communication to key stakeholders in the organization.	The artifact submission demonstrates communication to key stakeholders of the organization.
<i>Evaluate</i> if performance measures for each perspective addresses value creation for shareholder’s customers, employees and strategic partners.	The artifact submission <i>does not</i> evaluate if performance measures create value.	The artifact submission evaluates performance measures based on the value.
<i>Submit</i> a document that demonstrates understanding and evidence of the competency and PLG.	Artifact submission is <i>not</i> in an appropriate format and/or does not address all the required learning outcomes.	Artifact submission is submitted in an appropriate format and includes the required learning outcomes described above.

References

- AACSB. (2015). *Eligibility Procedures and Accreditation Standards for Business Accreditation*. Tampa, FL: AACSB International.
- Anderson, L. & Krathwohl, D. R. (2001). *A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Addison Wesley Longman.
- Blackboard and American Council on Education. (2014, December 5). *Clarifying Competency-Based Education Terms*. Retrieved from <http://bbbb.blackboard.com/Competency-based-education-definitions>
- Ford, K. (2014). *Competency-Based Education: History, Opportunities and Challenges*. Adelphi, Maryland: UMUC Center for Innovation in Learning and Student Success.
- Kilpatrick, J. D., Dean, K. L. & Killpartrick, P. (2008). Philosophical Concerns About Interpreting AACSB Assurance of Learning Standards. *Journal of Management Inquiry*, 17(3), 200-212.
- Klein-Collins, R. (2010). *Fueling the Race to Postsecondary Success: A 48-Institution Study of Prior Learning Assessment and Adult Student Outcomes*. Chicago: Council for Adult and Experiential Learning.
- Klein-Collins. (2013). *Sharpening Our Focus on Learning: The Rise of Competency-Based Approaches to Degree Completion*. Urbana, IL: National Institute for Learning Outcomes Assessment.
- Laitinen, A. (2012). *Cracking the Credit Hour*. New York: New American Foundation and Education Sector.
- Ryu, M. (2013). *Credit for Prior Learning: From Student, Campus, and Industry Perspectives*. Washington, D.C.: American Council on Education.
- Tate, P. & Klein-Collins, R. (2015). *PLA and CBE on the Competency Continuum: The Relationship between Prior Learning Assessment and Competency-Based Education*. Chicago: Council for Adult and Experiential Learning.

Pushing Forward: Finding and Using Meaningful Evidence of Beginning Teacher Competency

Mary Sowder

Utah Valley University

Abstract

As state and national scrutiny on teacher education has intensified, educator preparation programs (EPPs) are faced with the daunting task of providing evidence that their candidates are adequately prepared for effective classroom practice. Policy makers and accrediting agencies have started to rely heavily on linking teacher preparation programs to in-service teaching performance of their completers and then to K-12 student achievement to draw conclusions about the efficacy of EPPs. At the same time, some states and EPPs have chosen to use multiple and more nuanced measures for assessing program outcomes, including traditional observation instruments for classroom practices and professional dispositions, as well as standardized, performance-based measures of candidate learning, such as edTPA. The edTPA, a nationally available performance assessment for teacher candidates developed at the Stanford Center for Assessment, Learning, and Equity, has sparked some heated discourse

among teacher educators and teacher candidates. This paper attempts to reorient the discussion to look at the potential for the use of edTPA as a formative measure used for program improvement, as well as one measure for the summative assessment of teacher candidate proficiency. The story of one program's shift to considering program revision based less on faculty perceptions and biases and more on the collection and analysis of results is the focus of discussion and consideration within the broader issue of accountability for educator preparation programs.

As state and national scrutiny of teacher education has intensified, educator preparation programs (EPPs) are faced with the daunting task of providing evidence that their candidates are adequately prepared for effective classroom practice. Policy makers and accrediting agencies have started to rely heavily on linking teacher preparation programs to in-service teaching performance of their completers and then to K-12 student achievement to draw conclusions about the effectiveness of EPPs. At the same time, some states and EPPs have chosen to use multiple and more nuanced measures for assessing program outcomes, including traditional observation instruments for classroom practices and professional dispositions, as well as standardized, performance-based measures of candidate learning, such as the Educative Teacher Performance Assessment (edTPA).

What is edTPA?

edTPA, developed at the Stanford Center for Assessment, Learning, and Equity (SCALE), is a nationally available assessment designed by professional educators to assess beginning competencies of teacher candidates. edTPA is a subject- and grade level-specific assessment, which includes versions for 27 different teaching fields from elementary to high school grades. The assessment is designed to assess candidates' ability to use an authentic cycle of teaching aimed at specific learning goals, using evidence about 1) planning, 2) instruction, and 3) student assessment derived from candidates' practice in their student teaching or internship placement" (SCALE, 2013). Candidates submit evidence of their knowledge, skills, and practice including lesson plans, instructional materials, student assignments and assessments, feedback on student work, and unedited video recordings of instruction.

edTPA is aligned with the Interstate Teacher Assessment and Support Consortium standards for beginning teacher licensing and supports the goals of the Council for Accreditation of Educator Preparation

standards. The assessment was created with input from over 1000 teachers and teacher educators from across the United States, and more than 430 institutions of higher education participated in the design, development, piloting, and field testing of the assessment. Its national implementation began in Fall 2013 and has since grown to over 600 programs across 41 states (Pecheone & Whittaker, 2016).

edTPA portfolios may either be evaluated locally by selected stakeholders for formative purposes or institutions may ask candidates to submit their work for external scoring. For external scoring, Evaluation Systems of Pearson, SCALE's operational partner, provides secure electronic access to the edTPA assessment and manages the feedback system. Qualifications for scorers are determined by SCALE, and Pearson recruits scorers for each portfolio area (Pearson Education, n.d). Scorers must be elementary or secondary teachers or higher education educators with significant pedagogical content knowledge in the field in which they score. They must also have experience in working as instructors or mentors for novice teachers. Each edTPA scorer evaluates responses at the grade level and subject area for which he or she has qualified. Each scorer evaluates a candidate's entire portfolio by reviewing evidence from across the three assessment tasks.

Each task is evaluated with five separate rubrics representing distinctive elements of the task. "Evaluating the validity and reliability of edTPA as an instrument to measure teacher candidates' readiness to teach has been a continuous part of its rigorous, multi-year development process" (SCALE, 2013). Analysis of inter-rater reliability for edTPA in the 2013 field study ranged from 0.83 to 0.92. Multiple sources of evidence from the edTPA development process and data analyses collectively provide the foundation to support the content and construct validity of edTPA, documenting that the assessment is well aligned to the professional standards it seeks to measure, that it reflects the actual work of teaching, and that the score measures primary characteristics of effective teaching.

Discourse on Standardized Teacher Performance Assessment

There has been a great deal of public debate over the best way to prepare teachers and the best way to evaluate the effectiveness of teacher preparation programs. Some studies have attempted to identify characteristics of effective preparation on teachers' value added to student test score performance. Findings from Boyd et al. (2009) suggested that preparation programs requiring a capstone project (like edTPA) supplied significantly more effective first-year teachers. Other

educational policy makers have advocated the use of performance-based measures of teacher candidates' classroom competencies as formative measures of program effectiveness.

Although the desire to professionalize teaching and teacher education by using valid and reliable measures of teacher performance is shared by many teacher educators and policy makers, the use of a nationally standardized measure is a more controversial step toward the professionalization of teaching. Some authors argue that standardized teacher assessments, like edTPA, "corrupt the preparation process by discouraging authentic, multifaceted, longitudinal evaluations of candidate readiness, thereby undermining the very rigor and accountability they purport to ensure (Dover et al., 2015). The National Association for Multicultural Education (NAME) called on members to investigate how the edTPA undermines critical multicultural education and encouraged them to demand an end to the standardization and outsourcing of teacher candidate assessment (NAME, n.d.). Other educators are concerned about the "loss of local control and voice about teacher endorsement, issues related to privacy and ownership of portfolio data, and problems related to direct linking of teacher certification to a for-profit corporation [Pearson Education collects and stores data for edTPA portfolios.]" (Cochran-Smith et al., 2013).

Many of those in favor of the use of edTPA as a national assessment (Darling-Hammond & Hyler, 2013; Darling-Hammond et al., 1999) are leaders of the teacher education professionalization movement.

Just as in professions widely recognized for having a set of rigorous professional standards, such as law or medicine, teaching must raise standards for entry into the profession through a process similar to the bar process in law or the board process in medicine. By requiring all teacher candidates to pass a universal assessment, we ensure *all* teachers who enter the classroom, whether trained in a traditional program or alternatively certified, meet the same standards of competence." (American Federation of Teachers, 2013, p. 3)

Teacher performance assessment data can also be used to provide EPPs with evidence-based information that they can use in improving their programs (Peck et al., 2010; Zeichner, 2011) and serve as a form of learning for teacher candidates (Chung Wei & Pecheone, 2010; Darling-Hammond & Hyler, 2013).

This paper will look at the potential for the use of edTPA as a formative measure of assessment for program improvement and as con-

structive feedback for teacher candidates. The use of this particular standardized performance assessment for these purposes within the broader issue of the professionalization of teaching will be the focus of this discussion.

Using Evidence of Beginning Teacher Competency

The findings from this study were drawn from an ongoing series of investigations into the use of edTPA as a program requirement for teacher candidates in large, open-enrollment university in the western U.S. The research began with a request for funding for a pilot group of elementary education (EDEL) students in Fall 2015, and data are continuing to be collected as we expand the participant pool and refine assessment procedures in subsequent terms (Table 1). Students involved in the pilot in year one were serving as *intern* teachers, that is, they were elementary education students who were completing their program as full-time teachers of record in a local school district. Intern teachers have full responsibility for their own classroom with mentoring from a site coach and a university supervisor. Secondary candidates (EDSC) began to come on board with this assessment in Spring 2016. Candidates who did not participate in the edTPA during this time period completed the School of Education's traditional portfolio assessment.

Year	Participants (n)	Data Collected
Fall 2015	EDEL interns (n=73)	Performance data unavailable until Spring 2016
Spring 2016	Continuing Fall EDEL interns Spring EDEL student teachers (n=35) Secondary (EDSC) student teachers in math, health (n=11)	Performance results for Spring 2017 student teachers, Fall EDEL interns
Fall 2017	EDEL interns (n=56) Fall EDEL student teachers (n=37) EDSC Interns (n=35) EDSC student teachers in math, health (n=10)	Performance results for Fall 2017 student teachers
Spring 2018	Continuing Fall EDEL interns Spring EDEL Spring student teachers Continuing EDSC interns EDSC Spring student teachers	Performance results for interns, Spring student teachers

Analysis of the data for this article has been limited to the descriptive statistics generated from the scores assigned to the participants from the EDEL student group. The EDEL candidates were the first to pilot and the elementary program was the first to fully participate in the edTPA. Descriptive statistics (Table 2) for the scores generated from this group in Spring 2016 and Spring 2017 were used to encourage a variety of stakeholders (students, teachers, administrators, etc.) to reflect on the results and contribute ideas for program revision.

It should be noted that no single measure, like the edTPA, could by itself adequately evaluate individual candidates or a teacher preparation program (Feurer et al., 2013; Peck et al. 2014). However, for the teacher preparation program in which this study took place, edTPA group scores for each rubric provided a starting point to consider areas of the educator preparation program that appeared to be in need of revision. The identified areas were subsequently considered in conjunction with data from classroom observations and feedback from site-based teacher educators (cooperating teachers, instructional coaches, site administrators) and faculty members.

edTPA scoring

Once the data had been collected and analyzed, the research team was somewhat underwhelmed by the mean scores for each rubric. For the *Elementary Education* assessment, there are 15 subject-specific rubrics, five for each task. Each focuses on one measure of performance according to five performance levels that illustrate a progression as defined below (SCALE, 2017).

- Level 1—Represents the knowledge and skills of a seriously struggling candidate who is not ready to teach
- Level 2—Represents the knowledge and skills of a candidate who is possibly ready to teach.
- Level 3—Represents the knowledge and skills of a candidate who is qualified to teach.
- Level 4—Represents a candidate with a solid foundation of knowledge and skills for a beginning teacher
- Level 5—Represents the advanced skills and abilities of a candidate very well qualified and ready to teach.

The rubric levels are additive and correspond to an increase in the sophistication and variety of instructional skills and strategies along with more profound levels of reflection and analysis. They move from instruction with a teacher focus to teaching with a focus on student needs. They also move from whole-class teaching to teaching individuals and

Table 2 Elementary edTPA Rubric Scores						
Rubric	Low-High		Mode		Mean	
Year	2016	2017	2016	2017	2016	2017
1: Planning for Literacy Learning	2-4	1-5	3	3	2.70	2.94
2: Planning to Support Varied Student Learning Needs	1-4	1-5	3	3	2.56	2.97
3: Using Knowledge of Students to Inform Teaching and Learning	1-4	1-5	3	3	2.62	3.11
4: Identifying and Supporting Language Demands	1-4	1-5	3	3	2.66	3.00
5: Planning Assessments to Monitor and Support Student Learning	1-4	1-5	3	3	2.56	2.79
6: Learning Environment	1-4	1-5	3	3	3.06	3.07
7: Engaging Students in Learning	1-4	1-5	3	3	2.65	2.86
8: Deepening Student Learning	1-4	1-5	3	3	2.79	2.79
9: Subject-Specific Pedagogy	1-4	1-5	3	3	2.84	3.00
10: Analyzing Teaching Effectiveness	1-4	1-5	2	3	2.51	2.71
11: Analysis of Student Learning	1-4	1-5	3	3	2.63	2.88
12: Providing Feedback to Guide Further Learning	1-4	1-5	3	4	2.82	3.40
13: Student Use of Feedback	1-4	1-5	2	3	2.18	2.78
14: Analyzing Students' Language Use and Literacy Learning	1-4	1-5	2	3	2.41	2.81
15: Using Assessment to Inform Instruction	1-4	1-5	3	3	2.62	3.12
16: Analyzing Whole Class	1-4	1-5	2	3	2.28	2.78
17: Analyzing Individual Student Work Samples	1-4	1-5	2	3	2.48	2.90
18: Using Evidence to Reflect on Teaching	1-4	1-5	2	3	2.06	2.51

groups. The progression in the level of justification and analysis of teaching ranges from fragmented and indiscriminate at the lower levels, to intentional and carefully executed at the more advanced levels.

Identifying areas of concern

The scores reported for the pilot students in Spring 2016 (Table 2) showed only one area in which the mean score reached the 3.0 benchmark; by Spring 2017, that number had only increased to five areas with a score of 3.0 or better. Of even greater concern was the range of scores for each year. A small number of students received a score of only 1.0 each year in one or more areas. Although the mean score for each of these students still fell in the 2.0–2.5 range, it was disconcerting to faculty members that the students scored so low in any area of the assessment.

Of particular concern in the 2016 results were the scores on concerning feedback to students (rubric 13) and the analysis of the whole class and individual student learning (rubrics 14, 16–18). These results led to a discussion with the researchers centered on questions about how the program was addressing student learning in these areas. An informal survey of faculty members revealed that feedback to students was not an explicit element of any of program classes. Follow-up discussions with faculty determined that they felt that effective feedback *was* an important part of the teaching and learning process and that perhaps the content of program classes should be revised to include this skill. Some success with these efforts was reflected in the increased scores in this area in 2017 for rubrics 12 and 13.

The same process of reflection for how the candidates were prepared to analyze student learning from formative assessments revealed some larger concerns with how “assessment” and “analysis of student learning” were understood across different content areas. In some areas, assessment was limited to diagnostic or summative testing. The practice of embedded formative assessment practice was emphasized in several courses but was not consistently emphasized across all preparation programs within the School of Education. Although this disparity in views about the nature and use of assessment continues to influence of the candidates’ understanding of how and when to use a variety of assessment strategies, the 2017 scores did show some improvement in this area as well.

There were a few reassuring data points in the edTPA results for the candidates. The mode for each rubric for both years indicated that most of the students achieved a score of 3.0–3.9, within the range de-

fined by edTPA as being “qualified to teach.” When we compared pilot results to the national results, we found that the students were scoring slightly above the national average (Table 3). (Although the pilot candidates were not required to achieve any minimum passing score, we based this comparison on edTPA’s suggested minimum score of 42.) These data were used to address concerns of community members about how well teacher candidates prepared in an open-enrollment teaching institution would measure up against those from more prestigious research-one universities.

	Study Candidates	National Candidates
Average total score	46.88	44.3
Passing rate	76%	72%

Educative Teacher Performance Assessment

edTPA is an acronym for *educative* Teacher Performance Assessment. Initial experiences using this measurement of student learning as both a formative and summative tool have led us to believe that the process has been educative not only for candidates, but for faculty and other community members. Both students and instructors profited from exposure to national norms for professional practice. We have begun to practice the language common to the national conversation around professional teaching practices with the candidates and among faculty members. The tasks and rubrics have allowed students to engage with the same pedagogical content common to teacher candidates and educators across the country. The issues raised through participation in the edTPA process have initiated important conversations among faculty members and partner school districts about what is important for beginning teachers to know and be able to do. The results from the first two years of the edTPA process have revealed areas in need of revision in program content, and they have sparked discourse among faculty members around important issues in preparing teachers for the K-12 classroom. The importance of discussing the results and deciding whether they are of value to the department became an important part of faculty discussions. Changes were not implemented because of assessment results, the results brought areas for consideration to the attention of the faculty.

The move from edTPA “exploration and adoption to implementation and iterative refinement will ... provide a valuable framework for reflecting upon and planning for institutional change” (Lys et al., 2014). Challenges with edTPA-related workload for faculty and con-

necting specific elements of program to edTPA tasks will need to be addressed again as implementation grows. The desirability of participation in any nationally standardized assessment will continue to be debated. However, the edTPA has pushed us into important conversations about program curricula, and its tasks, its vocabulary, and its orientation to the teaching profession have influenced the growth of the teacher preparation programs, the faculty, and the teacher candidates.

References

American Federation of Teachers (2013). *Raising the bar: Aligning and elevating teacher preparation and the teaching profession*. Washington, DC: American Federation of Teachers. Retrieved April 1, 2017 from <http://www.aft.org/sites/default/files/news/raisingthebar2013.pdf>

Boyd, D., Grossman, P., Lankford, H., Loeb, S., & Wyckoff, J. (2009). Teacher preparation and student achievement. *Educational Evaluation and Policy Analysis*, 31(4), 416-440.

Chung Wei, R. & Pecheone, R. (2010). Assessment for learning in preservice teacher education. In M. Kennedy (Ed.), *Teacher Assessment and the Quest for Teacher Quality* (pp. 69–132). San Francisco: Jossey-Bass.

Cochran-Smith, M., Piazza, P. & Power, C. (2013). The politics of accountability: Assessing teacher education in the United States. *The Educational Forum*, 77(1), 6-27.

Darling-Hammond, L., & Hyler, M. E. (2013). The role of performance assessment in developing teaching as a profession. *Rethinking Schools*, 27(4), 10-15.

Darling-Hammond, L., Wise, A., & Klein, S. (1999). *A License to Teach: Raising Standards for Teaching*. San Francisco, CA: Jossey-Bass.

Dover, A. G., Schultz, B. D., Smith, K., & Duggan, T. J. (2015). Who's preparing our candidates? edTPA, localized knowledge and the outsourcing of teacher evaluation. *Teachers College Record*. Retrieved September 12, 2016 from <http://www.tcrecord.org/Content.asp?ContentId=17914>

Feuer, M., Floden, R., Chudowsky, N., & Ahn, J. (2013). *The evaluation of teacher preparation programs: Purposes, methods and policy options*. Washington, DC: National Academy of Education.

Lys, D., L'Esperance, M., Dobson, E., & Bullock, A. (2014). Large-Scale Implementation of the edTPA: reflections upon Institutional change in action. *Current Issues in Education*, 17(3), 1-12.

National Association of Multicultural Education (NAME). (n.d.) Retrieved April 1, 2017 NAME position statement on the edTPA. <https://www.nameorg.org/docs/Statement-rr-edTPA-1-21-14.pdf>

Pearson Education. (n.d.) edTPA scorer qualifications. Retrieved April 1, 2017 from <http://scoreedtpa.pearson.com/become-an-edtpa-scorer/edtpa-scorer-qualifications.html>.

Pecheone, R. & Whittaker, A. (2016). Well-prepared teachers inspire student learning. *Kappan*, 9(7), 8-13.

Peck, C., Gallucci, C., & Sloan, T. (2010). Negotiating implementation of high-stakes performance assessment policies in teacher education: From compliance to inquiry. *Journal of Teacher Education* 61(5), 451-460.

Peck, C.A., Singer-Gabella, M., Sloan, T., & Lin, S. (2014). Driving blind: Why we need standardized performance assessment in teacher education. *Journal of Curriculum and Instruction*, 8 (1), 8-30.

Stanford Center for Assessment, Learning and Equity (SCALE). (November 2013). *2013 edTPA Field Test: Summary Report*. Stanford, CA: Stanford Center for Assessment, Learning and Equity.

Stanford Center for Assessment, Learning and Equity (SCALE). (2017). *edTPA assessment handbook: Elementary education*. Stanford, CA: Stanford Center for Assessment, Learning and Equity.

Zeichner, K. (2011). Assessing state and federal policies to evaluate the quality of teacher preparation programmes. In P. Earley, D. Imig, and N. Michelli (Eds.), *Teacher Education Policy in the United States: Issues and Tensions in an Era of Evolving Expectations* (pp. 75-105). New York, NY: Routledge.

Utilizing Community-Engaged Experiential Learning and Service- Learning Pedagogy to Foster Increased Engaged Educational Experiences at Utah Valley University: A Research Proposal

Jonathan H. Westover

Utah Valley University

Abstract

While much has been said (often negatively) about the Millennial student and worker, research has shown that as a group they are high achieving, have a strong desire for ongoing personal and professional development, and tend to be seriously invested in making a marked sustainable impact on society and in the communities in which they live and work. One possible avenue to better engage Millennial students is through the use of community-engaged experiential learning (or service-learning) pedagogy in the classroom and projects in the community. Although service-learning is not a new phenomenon, this “civically engaged” experiential learning pedagogy has increased in

popularity and usage in educational settings in recent years. Additionally, community-engaged experiential learning and service-learning pedagogy can be utilized to provide meaningful community-service opportunities that simultaneously teach civic responsibility and encourage lifelong civic engagement, while also providing opportunities for significant real-life, hands-on learning of important skills and vital social understanding for Millennial students. This paper briefly reviews the many positive outcomes of service-learning pedagogy and then presents a research proposal for examining these and related questions and impacts for our Millennial students.

Introduction

I seek to foster increased collaboration across units (Academic Service-Learning, various Utah Valley University (UVU) colleges/schools, and individual departments) and cultivate the development of all courses into rich and rewarding high-impact and scalable service-learning course offerings. In an increasingly competitive higher education environment, meaningful community-engaged experiential learning courses are vital in meeting both the needs of today's diverse students and the strategic goals of UVU. Additionally, research across disciplines has clearly demonstrated that the use of service-learning pedagogy in the classroom has positive personal, social, learning, and career development outcomes for students, including increased student retention and completion rates.

As can be seen in the course completion data by delivery modality, semester, college/school, and service-learning vs. non-service-learning courses in Figures 1 and 2 in Appendix 1, campus-wide service-learning courses have a 6% higher completion rate (C- or better grade) than non-service-learning classes (84% to 90%). If just looking at hybrid courses campus-wide, there is a 20% difference (75% completion rate for non-service-learning hybrid courses and 95% completion for service-learning hybrid courses). Looking just at fully online courses campus-wide, there is a 7% difference (77% for non-service-learning online courses, 84% for service-learning online courses). Of course, there are differences in the gap by college/school, department, and subject area, hence the need to target those areas where the gap is the greatest. An additional detailed breakdown of course completion data can be seen via the link to an online interactive dashboard: https://viz.uen.org/t/uvu/views/gradesbymode2/College?%3Aembed=y&%3Adisplay_count=no.

As UVU is seeking to increase course and program completion and graduation rates of students (including increasingly turning to technology-enhanced online course delivery method to respond to increased student enrollments and course demand), it is imperative that we find ways to better engage students in 18 identified high drop-out/high enrolled courses so students can complete courses and move through their degree programs to graduation. The use of service-learning experiences is one high-impact engagement practice that is cheap, scalable, and adaptable to different disciplines and can be utilized to better a variety of student outcomes, including completion.

Review of Service-Learning Literature Outcomes

In addition to the clear positive impact of service-learning pedagogy on course completion and graduation (e.g., Reed et al., 2015; Lockeman & Pelco, 2013; Lockeman, 2012; Gallini & Moely, 2003), a vast array of previous research conducted across academic disciplines at a wide variety of educational institutions across the nation has demonstrated that the use of service-learning pedagogy has broad personal, social, learning, and career development outcomes for students (see in-depth annotated bibliography by Eyler & Giles, 2001), including:

Personal Outcomes

- Positive effect on student personal development such as sense of personal efficacy, personal identity, spiritual growth, and moral development
- Positive effect on interpersonal development and the ability to work well with others, leadership, and communication skills

Social Outcomes

- Positive effect on reducing stereotypes and facilitating cultural & racial understanding
- Positive effect on sense of social responsibility and citizenship skills
- Positive effect on commitment to service

Learning Outcomes

- Positive impact on students' academic learning
- Improves students' ability to apply what they have learned in "the real world"
- Positive impact on such academic outcomes as demonstrated complexity of understanding, problem analysis, critical thinking, and cognitive development

Career Development

- Contributes to student career development

Additionally, Warren (2012) expanded on the meta-analysis conducted by Novak et al. (2007) and found that service-learning does in fact increase student learning and has a positive influence on student learning outcomes irrespective of the way learning was measured. Additionally, previous research has demonstrated that students can learn many professional skills and concepts through the utilization of service-learning pedagogy:

technical or course content concepts (Robinson et al., 2010; McCrea, 2010; Larson & Drexler, 2010; Tucker & McCarthy, 2001)

effective communication skills (McCrea, 2010; Kenworthy-U'Ren, 2000)

relationship of course content to organization strategy (Robinson et al., 2010; McCrea, 2010; Larson & Drexler, 2010; Madsen & Turnbull, 2006; Rehling, 2000)

problem-solving (Robinson et al., 2010; Madsen & Turnbull, 2006; Zlotkowski, 1996)

time management, and networking skills (Litzky et al., 2010; Tucker et al., 1998)

analysis, synthesis, and evaluation (McCrea, 2010; Litzky et al., 2010; McGoldrick et al., 2000)

consequences of their own decisions (Larson & Drexler, 2010; McCrea, 2010; Waddock & Post, 2000)

cultural awareness and diversity (Keen and Hall, 2009; Vernon & Foster, 2002; Robinson, 1999)

teamwork, interaction, interpersonal, and communication skills (Madsen & Turnbull, 2006; Rehling, 2000; Michaelsen et al., 2000; Tucker et al., 1998)

conflict resolution and leadership skills (Kenworthy, 2010; Madsen & Turnbull, 2006)

learning how to learn (Westover, 2012; Munter, 2002)

Finally, in addition to the professional skills and concepts above, other positive outcomes of service learning include:

increased self-efficacy (Young et al., 2010; Fairfield, 2010; Madsen & Turnbull, 2006; Tucker & McCarthy, 2001)

increased social capital (Fairfield, 2010; D'Agostino, 2010)

enhanced social responsibility (Westover, 2012; Bowman et al., 2010; Kolenko et al., 1996)

increased exposure to career opportunities (Vroman et al., 2010; Fairfield, 2010; Robinson, 1999)

increased motivation to do well and learn (Fairfield, 2010; Madsen, 2004)

- increased personal confidence** (Rhee & Sigler, 2010; Fairfield, 2010; Konwerski & Nashman, 2002)
- increased desires to continue volunteerism** (Young et al., 2010; Butin, 2010; Bush-Bacelis, 1998)
- increased exploration of personal attitudes and values** (Rhee & Sigler, 2010; Fairfield, 2010; Madsen & Turnbull, 2006; Madsen, 2004; McGoldrick et al., 2000)
- increased personal and social development** (Fairfield, 2010; Simons, 2006)
- increased personal satisfaction and fulfillment** (Fairfield, 2010; Rehling, 2000)
- enhanced professional and real-world work experiences** (Robinson et al., 2010; Rhee & Sigler, 2010; McCrea, 2010; Larson & Drexler, 2010, Madsen, 2004; Gujarathi & McQuade, 2002)
- increased opportunity for students to become civically engaged in their communities** (Young et al. 2010; Butin, 2010; Rama et al., 2000; Godfrey, 1999).

Previous Success at UVU and Specific Target Goals and Objectives of the Proposal

The success of UVU academic service-learning is well documented on campus. Currently, there are nearly 200 UVU faculty across more the 350 course sections each year engaging more than 8000 students annually in high-impact community-engaged learning projects that enhance and deepen their experience with the course material and the underlying course objectives. Additionally, campus-wide service-learning courses have a 6% higher completion rate (C- or better grade) than non-service-learning classes (84% to 90%), with even stronger completion impact over non-service-learning courses in some of the campus individual colleges, schools, and individual departments.

Service-learning experiences are a high-impact engagement practice that is cheap, scalable, and adaptable to different disciplines and can be utilized to better a variety of student outcomes, including completion and graduation. This project will seek to infuse service-learning pedagogy into 16 courses to enhance student engagement, drive better learning outcomes, and increase course completion rates, student retention, and ultimately graduation rates.

The first order of business was to recruit faculty interested in being involved, receiving training, developing, implementing, and assessing their courses. I also recruited faculty course specialist mentors who assisted in the training, course development, implementation, and assessment. The next step was to train faculty and start the course devel-

opment process. Implementation of the first set of new service-learning courses took place during the Fall and Spring semesters of the 2016–2017 academic year, with assessment occurring concurrently. Ideally, this will be multi-year project that will allow for multiple semesters of course implementation and evaluation, with a rolling pool of new faculty being trained and developing their service-learning courses.

Ultimately, I was able to recruit 12 faculty members from 6 different departments and 3 of UVU's colleges and schools (overall 16 sections involved, with 565 enrolled students). Specific courses included College Success Studies (University College); Introduction to Business, Professional Business Presentations, Business Statistics, Organizational Behavior, and Social Media Marketing (Woodbury School of Business); and Introduction to Psychology and Intermediate Writing (College of Humanities and Social Sciences).

Methodology

To assess the proposed project's success and impact, I received Institutional Review Board approval to conduct a mixed-method longitudinal analysis, including a student pre/post-test attitudinal survey (each course, each semester), qualitative interviews with faculty participating in the project (before, during, and after the project), student learner reflections (each course, each semester), community partner evaluations (each course, each semester), and tracking of student retention and completion rates over time (ensuring the protection and anonymity of participants). Via pre/post-test administration of key attitudinal indicators and qualitative reflections, we will be able to measure the impact of service-learning projects on individual students for a range of student attitudes critical to student success. We will also be able to aggregate that data by course, department, and college/school and track aggregate-level changes over time to those important outcomes. Additionally, via community organization assessments, we can measure professional outcomes of student service-learning projects and their impacts on the community. This can also be tracked over time by discipline. See Appendices 2–4 for the assessment instruments.

Conclusion

Community-engaged experiential learning and service-learning experiences are a high-impact engagement practice that is cheap, scalable, and adaptable to different disciplines and can be utilized to better a variety of student outcomes, including completion and graduation. This research project will seek to infuse service-learning pedagogy into 16 identified high drop-out/high enrolled courses to enhance student

engagement, drive better learning outcomes, and increase course completion rates, student retention, and ultimately graduation rates. Additionally, as the current course completion discrepancy between service-learning and non-service-learning classes is generally around 6% (averaged across campus) and even wider among 18 identified high drop-out/high enrolled courses, I will seek to improve completion rates in those classes by at least 6% within two years.

References

- Bowman, N. A., Brandenberger, J. W., Mick, C., & Smedley, C. (2010). Sustained immersion courses and student orientations to equality, justice, and social responsibility: The role of short-term service-learning. *Michigan Journal of Community Service Learning, 17*(1), 20-31.
- Bush-Bacelis, J. L. (1998). Innovative pedagogy: Academic service-learning for business communication. *Business Communication Quarterly, 61*(3), 20-34.
- Butin, D. W. (2010). *Service-Learning in Theory and Practice: The Future of Community Engagement in Higher Education*. New York: Palgrave Macmillan.
- D'Agostino, M. J. (2010). Measuring social capital as an outcome of service learning. *Innovative Higher Education, 35*(5), 313-328.
- Eyler, J. & Giles, D. (2001). *At a Glance: What We Know About the Effects of Service-Learning on College Students, Faculty, Institutions, and Communities, 1993–2000* (3rd Ed.). Washington, DC: Corporation for National and Community Service.
- Fairfield, K. D. (2010). Growing up and growing out: Emerging adults learn management through service-learning. *Journal of Management Education, 34*(1), 113-141.
- Gallini, S. M., & Moely, B. E. (2003). Service-learning and engagement, academic challenge, and retention. *Michigan Journal of Community Service Learning, 10*(1), 5-14.
- Godfrey, P. C. (1999). Service-learning and management education: A call to action. *Journal of Management Inquiry, 8*, 363-379.

Gujarathi, M. R., & McQuade, R. J. (2002). Service-learning in business schools: A case study in an intermediate accounting course. *Journal of Education for Business, 77*(3), 144-151.

Keen, C., & Hall, K. (2009). Engaging with difference matters: Longitudinal student outcomes of co-curricular service-learning programs. *Journal of Higher Education, 80*(1), 59-79.

Kenworthy, A. L. (2010). Service-learning and negotiation: An educational "win-win." *Journal of Management Education, 34*(1), 62-87.

Kenworthy-U'Ren, A. L. (2000). Management students as consultants: A strategy for service learning in management education. In P. C. Godfrey & E. T. Grasso (Eds.), *Working for the Common Good: Concepts and Models for Service-Learning in Management* (pp. 55-67). Washington, DC: American Association for Higher Education.

Kolenko, T. A., Porter, G., Wheatley, W., & Colby, M. (1996). A critique of service learning projects in management education: Pedagogical foundations, barriers, and guidelines. *Journal of Business Ethics, 15*(1), 133-142.

Konwerski, P., & Nashman, H. (2002). Who teaches whom: The varied voices and instructional roles of community service-learning partners. *Journal of Nonprofit & Public Sector Marketing, 10*(2), 165-186.

Larson, E. & Drexler, J. A. (2010). Project management in real time: A service-learning project. *Journal of Management Education, 34*(4), 551-573.

Litzky, B. E., Godshalk, V. M., & Walton-Bongers, C. (2010). Social entrepreneurship and community leadership: A service-learning model for management education. *Journal of Management Education, 34*(1), 142-162.

Lockeman, K. S. (2012). *The Impact of Service-Learning among Other Predictors for Persistence and Degree Completion of Undergraduate Students*. Doctoral dissertation, Virginia Commonwealth University Richmond, VA.

Lockeman, K. S., & Pelco, L. E. (2013). The relationship between service-learning and degree completion. *Michigan Journal of Community Service Learning, 20*(1), 18-30.

Madsen, S. R. (2004). Academic service learning in human resource management education. *Journal of Education for Business, 79*(6), 328-332.

Madsen, S. R. & Turnbull, O. (2006). Academic service learning experiences of compensation and benefits course students. *Journal of Management Education, 30*(4), 724-742.

McCrea, E. A. (2010). Integrating service-learning into an introduction to entrepreneurship course. *Journal of Management Education, 34*(1), 39-61.

McGoldrick, K., Battle, A., & Gallagher, S. (2000). Service-learning and the economics course: Theory and practice. *American Economist, 44*(1), 43-53.

Michaelsen, L. K., Kenderdine, J. M., Hobbs, J., & Frueh, F. L. (2000). The Oklahoma integrated business core: Using a service-learning experience as a foundation for undergraduate business education. In P. C. Godfrey & E. T. Grasso (Eds.), *Working for the Common Good: Concepts and Models for Service-Learning in Management* (pp. 149-166). Washington, DC: American Association for Higher Education.

Munter, J. (2002). Linking community and classroom in higher education: Service-learning and student empowerment. *Journal of Nonprofit & Public Sector Marketing, 10*(2), 151-164.

Novak, J.M., Markey, V., & Allen, M. (2007). Evaluating cognitive outcomes of service learning in higher education: A meta-analysis. *Communication Research Reports, 24*(2), 149-157.

Rama, D. V., Ravenscroft, S. P., Walcott, S. K., & Zlotkowski, E. (2000). Service-learning outcomes: Guidelines for educators and researchers. *Issues in Accounting Education, 15*, 657-693.

Reed, S. C., Rosenberg, H., Statham, A., & Rosing, H. (2015). The effect of community service learning on undergraduate persistence in three institutional contexts. *Michigan Journal of Community Service Learning, 21*(2), 22.

Rehling, L. (2000). Doing good while doing well: Service learning internships. *Business Communication Quarterly*, 63(1), 77-89.

Rhee, K. S. & Sigler, T. H. (2010). Developing enlightened leaders for industry and community: Executive education and service-learning. *Journal of Management Education*, 34(1), 163-181.

Robinson, D. F., Sherwood, A. L., & DePaolo, C. A. (2010). Service-learning by doing: How a student run consulting company finds relevance and purpose in a business strategy capstone course. *Journal of Management Education*, 34(1), 88-112.

Robinson, G. (1999). Stepping into our destiny: Service learning in community colleges. *Community College Journal*, 70(5), 8-12.

Simons, L. (2006). The influence of service learning on students' personal and social development. *College Teaching*, 54(4), 307.

Tucker, M. L., & McCarthy, A. M. (2001). Presentation self-efficacy: Increasing communication skills through service-learning. *Journal of Managerial Issues*, 13, 227-245.

Tucker, M. L., McCarthy, A. M., Hoxmeier, J. A., & Lenk, M. M. (1998). Community service learning increases communication skills across the business curriculum. *Business Communication Quarterly*, 61(2), 88-99.

Vernon, A., & Foster, L. (2002). Nonprofit agency perspectives of higher education service learning and volunteerism. *Journal of Nonprofit & Public Sector Marketing*, 10, 207-230.

Vroman, K., Simmons, C., & Knight, J. (2010). Service learning can make occupation-based practice a reality: a single case study. *Occupational Therapy in Health Care*, 24(3), 249-265.

Waddock, S., & Post, J. (2000). Transforming management education: The role of service learning. In P. C. Godfrey & E. T. Grasso (Eds.), *Working for the Common Good: Concepts and Models for Service-Learning in Management* (pp. 43-54). Washington, DC: American Association for Higher Education.

Warren, J. L. (2012). Does service-learning increase student learning? A meta-analysis. *Michigan Journal of Community Service Learning, 18*(2), 56-61.

Westover, J. H., ed. (2012). *Academic Service-Learning across Disciplines: Models, Outcomes, and Assessment*. Champaign, IL: The Learner.

Young, M. A., Weber, J. E., & Weber, P. S. (2010). Measuring service learning outcomes: Test-retest reliability of four scales. *Psychological Reports, 107*(2), 611-616.

Zlotkowski, E. (1996). Opportunity for all: Linking service-learning and business education. *Journal of Business Ethics, 15*(1), 5-20.

Appendix 1: UVU Service & Engaged Learning Course Completion

Figure 1: Course completion by delivery method and college/school, all classes

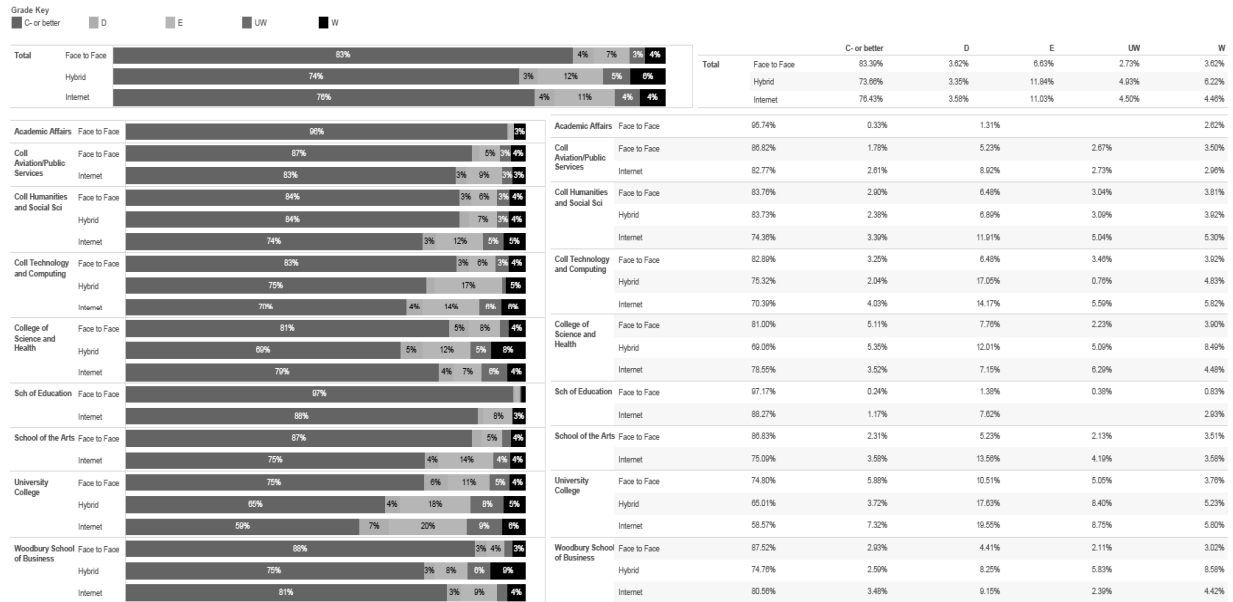
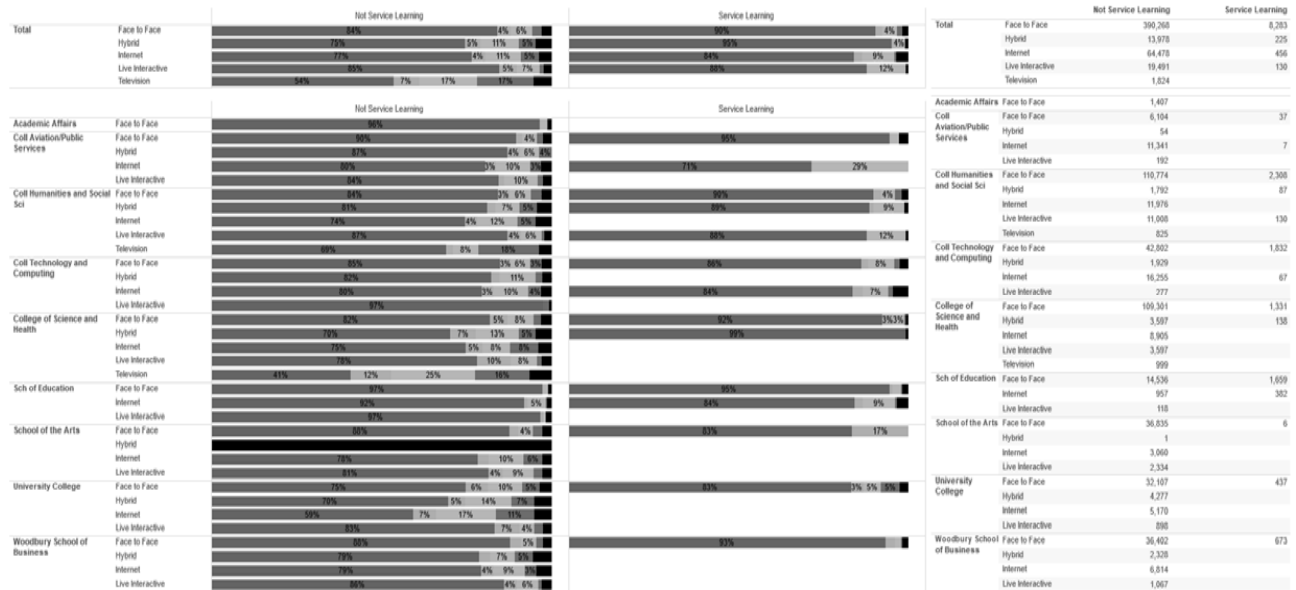


Figure 2: Course completion by delivery method and college/school, all classes, sl vs non sl



Appendix 2: Service & Engaged Learning Student Attitudes Pre-Test/Post-Test

(Form adapted for online data collection)

Student Directions: You are about to participate in a service-learning class and will invest time in “volunteering” your marketing skills toward helping a business by building an annual marketing plan. Using the 7-point scale below, please indicate how important or accurate each of the following possible reasons for volunteering via a service learning class is for you. Please place the number corresponding to how important/accurate each statement is on the line preceding the statement.

1 2 3 4 5 6 7

1=Not at all important/accurate for you; 7=Extremely important/ accurate for you.

1. Volunteering can help me get my foot in the door at a place where I would like to work.
2. My friends volunteer.
3. I am concerned about those less fortunate than myself.
4. People I'm close to want me to volunteer.
5. Volunteering makes me feel important.
6. People I know share an interest in community service.
7. No matter how bad I've been feeling, volunteering helps me to forget about it.
8. I am genuinely concerned about the particular group I am serving.
9. By volunteering, I feel less lonely.
10. I can make new contacts that might help my business or career.
11. Doing volunteer work relieves me of some of the guilt over being more fortunate than others.
12. I can learn more about the cause for which I am working.
13. Volunteering increases my self-esteem.
14. Volunteering allows me to gain a new perspective on things.
15. Volunteering allows me to explore different career options.
16. I feel compassion toward people in need.
17. Others with whom I am close place a high value on community service.
18. Volunteering lets me learn through direct “hands on” experience.
19. I feel it is important to help others.
20. Volunteering helps me work through my own problems.

21. Volunteering will help me succeed in my chosen profession.
22. I can do something for a cause that is important to me.
23. Volunteering is an important activity to help the people I know the best.
24. Volunteering is a good escape from my own troubles.
25. I can learn how to deal with a variety of people.
26. Volunteering makes me feel needed.
27. Volunteering makes me feel better about myself.
28. Volunteering experience will look good on my resume.
29. Volunteering is a way to make new friends.
30. I can explore my own strengths.

CIVIC ATTITUDES

Please use the following 5-point scale to answer the following statements, placing the number corresponding to your level of agreement/disagreement on the line preceding the statement.

1 2 3 4 5 6 7

1=Strongly disagree; 5=Strongly agree

To what extent do you agree or disagree with the following statements?

1. Adults should give some time for the good of their community or country.
2. People, regardless of whether they have been successful or not, ought to help others.
3. Individuals have a responsibility to help solve our social problems.
4. I feel that I can make a difference in the world.
5. It is important to help others even if you don't get paid for it.

Appendix 3: End-of-Semester Student Self-Assessment

(Form adapted for online data collection)

1. Please describe your experience of RECIPROCITY during your S&EL.

What did you “give” to the client agency or client of the agency relative to what you received through doing this S&EL, if anything?

What did your client teach you and what did you teach your client in return?

How could this aspect of S&EL be enhanced?

2. Please describe your experience of REFLECTION during your S&EL project.

Was this experience different in some substantive way from your experience in other courses, and if so, how and why?

What would you do differently if you were to do another group S&EL project in the future to make the experience more positive for yourself, as well as for everyone else involved?

How could this aspect of S&EL be enhanced?

3. Please describe your experience of REALITY during your S&EL project.

Was this experience different in some substantive way from your experience in other courses, and if so, how and why?

To what degree did your S&EL experience enable you to apply and learn about the course material or major course concepts this semester?

How could this aspect of S&EL be enhanced?

4. Please describe your experience of RESPONSIBILITY to your client, teammates, or others during your S&EL project.

Was this experience different in some substantive way from your experience in other courses, and if so, how and why?

Has your experience in this S&EL project changed your perception of your role as a socially responsible citizen?

How could this aspect of S&EL be enhanced?

5. Please comment about REWARDS OF SYNERGY as this concept relates to your own experience this semester. Is S&EL a useful part of a business school program, and if so, why and how?

What is the most significant learning experience that you take away from this S&EL project?

How could your experience with S&EL be enhanced to make it more useful to you?

Appendix 4: UVU Service & Engaged Learning Community Client Evaluation

(Form adapted for online data collection)

Thank you very much for giving your time and energy this semester in working with our UVU Students. Our students' involvement with your organization has enriched their learning experience and will help them to be better prepared for their future careers. We deeply appreciate your contribution toward their professional development and growth.

Please take a little care and time (about 10-20 minutes) to complete this questionnaire in an effort to provide valuable feedback with which to improve this academic program for future clients.

Please respond to the following statements as objectively as you can as they relate to your involvement with this project during the semester.

The ratings for the scale are:

0 = very unsatisfying

1 = unsatisfying

2 = somewhat unsatisfying

3 = somewhat satisfying

4 = satisfying

5 = very satisfying

Students':	0	1	2	3	4	5
understanding of the specific problem/question your company posed						
attitudes						
self-motivation						
project planning						
organizational skills						
communications skills						
leadership skills						
sense of responsibility						
emotional maturity						
time management						
team work						
task completion						
professional approach/professionalism (incl. attire for meetings of all kinds)						
quality of final project						
value of this project for your firm						

1. Did you learn important information that you believe will help you to grow your organization in the future? Please elaborate.

2. Do you plan to implement (some of the ideas) presented to you in their recommended solutions?

A. Please describe what you believe will add the most value to your organization.

B. Can you quantify the approximate monetary value (in US\$) this project could/will/has generated for your company?

C. What do you anticipate to have less/little/no value to you?

3. Please provide any comments that you would like to share about how to improve this project for you in the future:

4. Please comment on your interactions with the UVU student(s) working on your project this semester:

What went wrong?

B. What went right?

C. How could this experience be improved for you in a future project with our students?

D. Any other comments?

5. Is there another future project related to your firm with which UVU students may be able to assist you? Please describe it briefly:

Application of Orthogonal Frequency Division Multiplexing Techniques to Photographic Media

Ethan Albretsen and Fon Brown

Weber State University

Abstract

A spatial application of orthogonal frequency division multiplexing (OFDM) is explored that encodes and decodes digital data using photographic media. Photographic media typically lacks pixel density but provides superior color depth. Using grayscale images, the printing and scanning process was studied to characterize the transfer function of the overall transmission process. Data were then encoded into symbols with 8-PSK using 10 spatial frequencies in two dimensions. A cyclic border (the spatial equivalent to the cyclic prefix) was added to account for spatial transients. A means for synchronization and skew correction was embedded in the photograph to accurately identify the boundaries of each symbol. Images were rendered photographically, scanned back, and decoded. The relationship between image size and bit error rate was then studied to determine the bit density that can practically be achieved using this approach. Results suggest that the bit density is comparable to quick response (QR) code.

I. Introduction

Techniques such as barcodes and quick response (QR) codes are commonly used as a means of encoding data onto print media. This media can then be scanned later to retrieve the data. Standard barcodes store data only in one direction and have very limited capacity. Two-dimensional codes store much more data using two directions (Figure 1). Either way, these codes typically encode data using only two colors in much the same way that non-return-to-zero (NRZ) codes encode data using only two voltages. Such codes are appropriate for print media where spatial bandwidth is high, but they are not suitable for photographic media where spatial bandwidth is low and color depth (the number of possible pixel colors) is high.



Figure 1. Codes that store data in one dimension (left) and two dimensions (right).

This paper introduces a new technique for encoding information on photographic media. The method is called orthogonal spatial frequency coding (OSFC), and it encodes information using the phase and amplitude of two-dimensional sinusoids at orthogonal spatial frequencies.

II. Theory











In the context of OSFC, a symbol, X_i , is the sum of N two-dimensional orthogonal sinusoids, each encoding an M -bit word.

$$X_i(x, y) = \sum_{j=1}^N A_{i,j} \cos\left(\frac{2\pi m_j x}{d} + \frac{2\pi n_j y}{d} + \theta_{i,j}\right), \quad 1 \leq j \leq N \quad (1)$$

The choice of N is a design decision based on the noise and quantization of the media; d is the nominal size of the rendered symbol. The value of M is dictated by the constellation chosen to encode the data. For example, 16-QAM encodes 4 bits per word whereas 8-PSK en-

codes 3. Let $W_{i,j}$ denote the M-bit data word associated with sinusoid j in symbol i . $A_{i,j}$ and $\theta_{i,j}$ in Equation (1) come directly from the location of $W_{i,j}$ in the constellation, whereas the spatial frequencies n_j and m_j are based on j and are determined a priori (as an example, see Table 1).

Table 1. Example basis sinusoids

j	n_j	m_j	$f_j(x,y)$	j	n_j	m_j	$f_j(x,y)$
0	1	0		5	0	2	
1	0	1		6	2	1	
2	1	1		7	2	-1	
3	1	-1		8	1	2	
4	2	0		9	1	-2	

Some interval of this symbol is then rendered to photographic media and is eventually rescanned. This rendering and scanning process introduces transfer function $H(\omega_x, \omega_y)$, or equivalently, point spread function $h(x, y)$. The scanned symbol, y_i , can be modeled:

$$y_i(x, y) = x_i(x, y) * h(x, y) + n(x, y) \tag{2}$$

where $n(x,y)$ is the noise. The effective radius, r , of $h(x,y)$ indicates the extent to which the border of any rendered and scanned symbol will be affected by its surroundings. So, if $x_i(x,y)$ is rendered over the interval $[-r, d+r] \times [-r, d+r]$, $y_i(x,y)$ will be indistinguishable over the interval $[0, d] \times [0, d]$ from what it would have been had $x_i(x,y)$ been rendered over \mathbb{R}^2 . We may therefore consider $y_i(x,y)$ over the range $[0, d] \times [0, d]$ to be one period of an infinite periodic function. The portion of $x_i(x,y)$ rendered outside $[0, d] \times [0, d]$ is called the *cyclic border* (Figure 2).

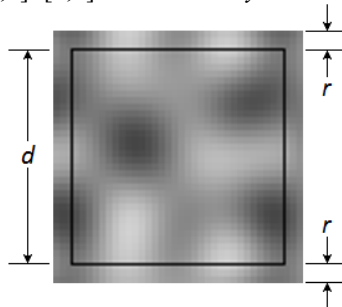


Figure 2. Nominal symbol and cyclic border rendered over $[-r, d+r] \times [-r, d+r]$. The black outline around the nominal symbol has been added only to illustrate the extent of the cyclic border.

The spatial frequency domain equivalent of Equation (2) is given by

$$y_i(\omega_x, \omega_y) = X_i(\omega_x, \omega_y)H(\omega_x, \omega_y) + N(\omega_x, \omega_y) \quad (3)$$

Note that since $x_i(x,y)$ and $y_i(x,y)$ are considered to be periodic, $X_i(\omega_x, \omega_y)$ and $Y_i(\omega_x, \omega_y)$ may be assumed to be discrete. Once $H(\omega_x, \omega_y)$ has been characterized, an estimate of $X_i(\omega_x, \omega_y)$ can be found:

$$\hat{X}_i(\omega_x, \omega_y) = \frac{Y_i(\omega_x, \omega_y)}{H(\omega_x, \omega_y)} = X_i(\omega_x, \omega_y) + \frac{N(\omega_x, \omega_y)}{H(\omega_x, \omega_y)} \quad (4)$$

The problem with this estimate is that noise is amplified for those spatial frequencies where the magnitude of $H(\omega_x, \omega_y)$ is small. Fortunately, we are only interested in the N discrete frequency points where $\omega_x = 2\pi n_j/d$ and $\omega_y = 2\pi m_j/d$. (It is prudent to choose n_j and m_j so that the magnitude of $H(2\pi n_j/d, 2\pi m_j/d)$ is large.) All that remains of the decoding process, then, is to estimate each W_{ij} by finding the constellation point nearest $\hat{X}_i(2\pi n_j/d, 2\pi m_j/d)$.

III. Transfer Function

There are two reasons it is necessary to characterize the transfer function (or, equivalently, the point spread function) for the system. First, the transfer function is needed to compensate for the frequency-dependent attenuation in the scanned image. Second, the effective radius of the point spread function is needed to determine the appropriate width of the cyclic border. To find the transfer function, white and black lines of various thicknesses were rendered both horizontally and vertically using a Fujifilm LP5900 photofinisher with a resolution of 301 dpi. The photographs were then scanned using a Cannon CanoScan 9000F scanner with a resolution of 1200 dpi (Figure 3). Amplitudes of the scanned images were analyzed to determine the spatial frequency response of the system (Table 2).

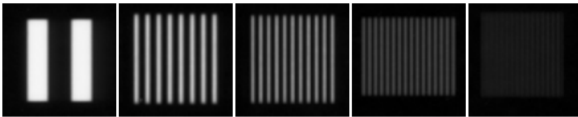


Figure 3. Amplitude attenuation as a function of (horizontal) spatial frequency. (a) 0.18 mm^{-1} , (b) 1.5 mm^{-1} , (c) 2 mm^{-1} , (d) 3 mm^{-1} , (e) 6 mm^{-1} .

Table 2. Observed Attenuation (Normalized)			
Frequency		Amplitude	
mm⁻¹	rad/mm	x	y
0.37	2.36	0.943	0.957
1.5	9.42	0.745	0.780
2.0	12.6	0.612	0.645
3.0	18.8	0.397	0.422
6.0	37.7	0.163	0.168

Analysis of the amplitude data reveals that the frequency response curve in x and y have the form:

$$H_x(\omega_x) = \frac{\omega_{x0}^2}{\omega_x^2 + \omega_{x0}^2}, \text{ and } H_y(\omega_y) = \frac{\omega_{y0}^2}{\omega_y^2 + \omega_{y0}^2} \quad (5)$$

where $\omega_{x0} = 8.23 \text{ rad/mm}^{-1}$ and $\omega_{y0} = 8.55 \text{ rad/mm}^{-1}$ (Figure 4). The transfer function, $H(\omega_x, \omega_y)$, is assumed to be separable, so it can be obtained by

$$H(\omega_x, \omega_y) = H_x(\omega_x)H_y(\omega_y). \quad (6)$$

The point spread function $h(x,y)$ is obtained by taking the inverse Fourier transform of the transfer function (Figure 5). Analysis shows that 95% of the volume of the point spread function falls within a radius of 0.25 mm. The cyclic boarder was therefore chosen to be 0.25 mm or 3 (photofinisher) pixels.

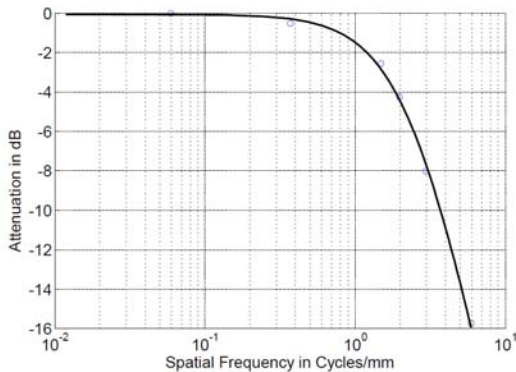


Figure 4. Frequency response of photographic media in the horizontal (x) direction.

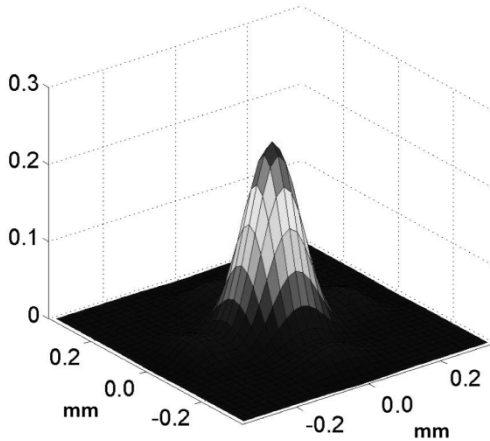


Figure 5. Point spread function $h(x,y)$

IV. Framing

For the decoding process to work, the origin and shape of each scanned symbol must be accurately determined. This can be a difficult problem because of aspect and keystone distortions that may be introduced by rendering and/or scanning devices. This problem can be addressed if we locate the corners of each symbol and use them to map the distorted symbol back to a square. The corners are not difficult to find if the symbols are *framed* when they are rendered. One suitable framing technique is to surround each rectangular group of symbols with four fixed-width borders, each having a sinusoidal intensity profile.

The border sinusoids are positioned so that two full periods equal the size (in each direction) of a rendered symbol, and the phase of each sinusoid is such that symbols are aligned to $\theta=0, 4\pi, 8\pi$, etc. When a group of symbols are scanned, horizontal and vertical lines are cast within and generally parallel to the top, bottom, left, and right borders. A modified Prony method is used to fit a sinusoid to the intensity of the border along each line. However, rather than using the points that correspond to $\theta=0, 4\pi, 8\pi$, etc., to find the symbol corners, a more direct approach is to use the points that correspond to $\theta = \theta_k, \theta_k + 4\pi, \theta_k + 8\pi$, etc., where

$$\theta_k = \frac{4\pi(Lr + kd)}{L(d + 2r)}, \quad k \in \{0 \dots L - 1\}. \quad (7)$$

Construction lines are then formed from corresponding points in opposite borders, and the intersections of these lines establish an $L \times L$ grid of sample points for each symbol (Figure 6). The symbols can then be resampled, essentially mapping them to an $L \times L$ square. It should be noted that this technique is largely insensitive to the choice of initial horizontal and vertical lines, so long as those lines stay within their respective borders.

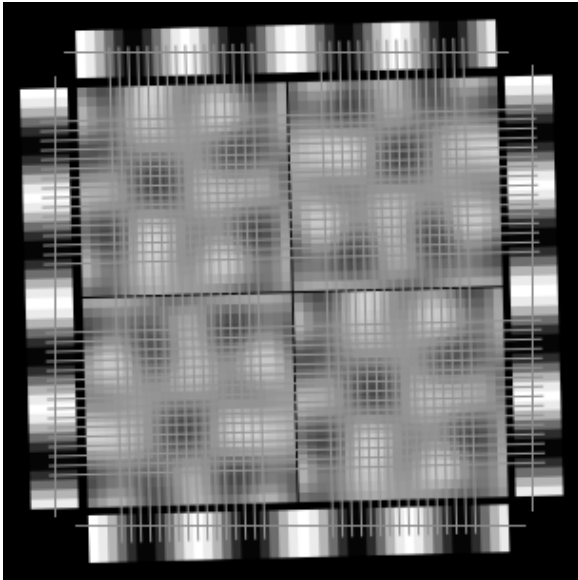


Figure 6. Locating sample points using a sinusoidal border.

V. Results

A data set of 300 bits was encoded in 10 symbols using an 8-PSK constellation and the 10 basis sinusoids shown in Table 1. The symbols were photographically rendered on a Fujifilm LP5900 using three different nominal symbol sizes: 16×16 pixels, 24×24 pixels, and 32×32 pixels. The photographs were then scanned and decoded using a Cano-Scan 9000F. Scatter plots of $\hat{X}_i(2\pi n/d, 2\pi m/d)$ were collected for each symbol size to show the decoding results before discretization (Figure 7). Not surprisingly, the larger symbol sizes exhibit more coherent clustering.

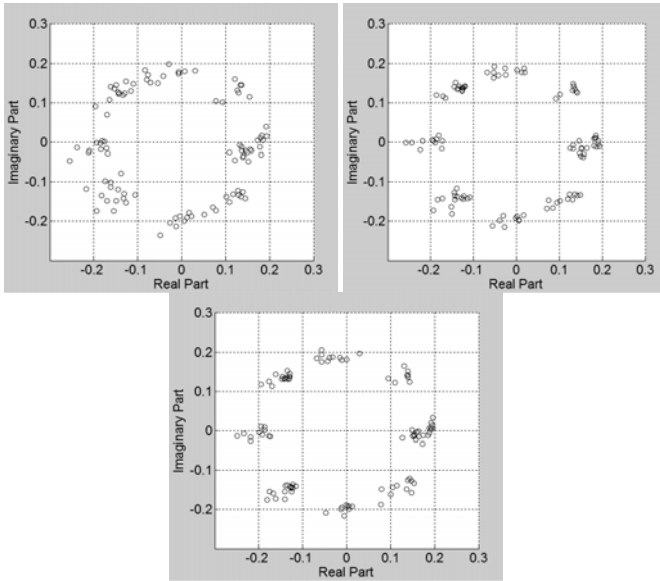


Figure 7. Scatter plots of $\hat{X}_i(2\pi n_j/d, 2\pi m_j/d)$ $i, j \in \{1 \dots 10\}$, (top left) 16×16 pixel symbols, (top right) 24×24 pixel symbols, and (bottom) 32×32 pixel symbols

Six data points decoded from the 16×16 symbols were off by more than 22.5° and were decoded incorrectly. However, none were off by more than 67.5° so all six were single-bit errors. No errors were encountered from the 24×24 and 32×32 symbol sizes. The number of errors and the bit error rate (BER) are summarized in Table 3. The data were further analyzed to determine the signal-to-noise ratio (SNR) and phase angle error (PAE). The mean and standard deviation of the PAE, along with the SNR are also summarized in Table 3. Finally, the area of each symbol (including the cyclic border) and the bit density are included for convenience.

Table 3. Summary of Results							
Symbol Size	Errors	BER	SNR (dB)	μ_{PAE}	σ_{PAE}	Area (mm ²)	Bit density (bits/in ²)
16×16	6/300	0.02	14.2	- 0.3°	10.4°	3.45	5580
24×24	0/300	0.00	17.1	- 0.9°	7.4°	6.41	3000
32×32	0/300	0.00	17.9	1.2°	6.8°	10.3	1870

VI. Conclusion

OSFC can be used to encode data on photographic media. Some errors were observed in the most dense format tested, but the error rate was low (2%). The bit density of the most dense OSFC format tested (5580 bits/in²) is comparable with that of QR code (5224 bits/in², version 19 without error correction). This is significant, especially given the inferior spatial bandwidth of the photographic media.

References

- [1] A. Grillo, A. Lentini, M. Querini, and G. F. Italiano, "High capacity colored two dimensional codes," Proceedings of the International Multiconference on Computer Science and Information Technology, Wisla, 2010, pp. 709-716.
- [2] R. Kumaresan, D. W. Tufts and L. L. Scharf, "A Prony method for noisy data: Choosing the signal components and selecting the order in exponential signal models," in Proceedings of the IEEE, vol. 72, no. 2, pp. 230-233, February 1984.
- [3] S. Weinstein and P. Ebert, "Data transmission by frequency-division multiplexing using the discrete Fourier transform," in IEEE Transactions on Communication Technology, vol. 19, no. 5, pp. 628-634, October 1971.

Simple Strength of Material Experiment to Evaluate the Deflection of a Beam

Jacob Carter and Ali Siahpush
Southern Utah University

SUMMARY

In engineering applications, when different components such as beams, columns, or foundations are used, they are normally designed within certain limits. These limitations are based on the following: safety factor, environment, loads, allowable stress, deflection, mechanical properties of the material, etc. The design of such beams can be complex but is intended to ensure the beam can safely carry the required load. The purpose of this paper is to discuss the fundamentals of beam deflection, representing the first step in a series of research topics based in strength of materials. A simple method (integration method) based on the load is used to evaluate the amount of deflection and slope at the free end of beams. This analytical method is then compared with the experimental results and discrepancies are discussed.

INTRODUCTION

Structures cannot be created without engineering theory, and design rules have existed from the earliest times for building structures such as Greek temples, Roman aqueducts, and Gothic cathedrals—and later for steel skyscrapers and the frames for aircraft. In the 17th century, Galileo was the first to introduce recognizably modern science into the calculation of structures; he determined the breaking strength of beams. But with the discovery of “The Codex Madrid” in the National Library of Spain in 1967, it was found that Leonardo da Vinci’s work (published in 1493) had not only preceded Galileo’s work by over 100 years, but had also, unlike Galileo, correctly identified the stress and strain distribution across a section in bending [1].

In the 18th century, engineers moved away from this “ultimate load” approach, and early in the 19th century, a formal philosophy of design had been established—a structure should remain elastic, with a safety factor on stress built into the analysis. This philosophy held sway for over a century, until the first tests on real structures showed that the stresses confidently calculated by designers could not actually be measured in practice. Structural engineering has taken a completely different path since the middle of the 20th century; plastic analysis reverts to Galileo’s objective of the calculation of ultimate strength, and powerful new theorems now underpin the activities of the structural engineer [2]. (For the history of beam deflection, refer to *History of Strength of Materials* by Stephen P. Timoshenko [3].)

In some engineering problems, the maximum load may not be a restriction, but the amount of deflection under operation is. The deflection of a beam must often be limited to provide integrity and stability to the structure. The beams may be made from steel, aluminum, timber, or reinforced concrete and have a cross-sectional shape that can be rectangular or T- or I-shaped. The design of such beams can become complex but is imperative for the beam to safely carry the required load.

THEORY OF DEFLECTION

In this analysis, the following assumptions are undertaken to present the fundamental relationship between loads and deflections.

- The beam is in a horizontal position.
- The beam support is cantilever, fixed on one end and free on the other end.
- The weight of the beam has minimal effect on the beam deflection.

- The equation is valid only for beams that are not stressed beyond the elastic limit.
- The deflection and the deflection angle of the loaded beam are small.

The cantilever beam shown in Figure 1, under the end load P , is deflected. The relationship between the end deflection (v_A) and the force (P) may be expressed as [4, p. 582]:

$$v_A = \frac{PL^3}{3EI} \tag{1}$$

where L is the length of the beam (m), E is the modulus of elasticity of the solid beam (N/m^2 or Pa), and I is the area moment of inertia (m^4).

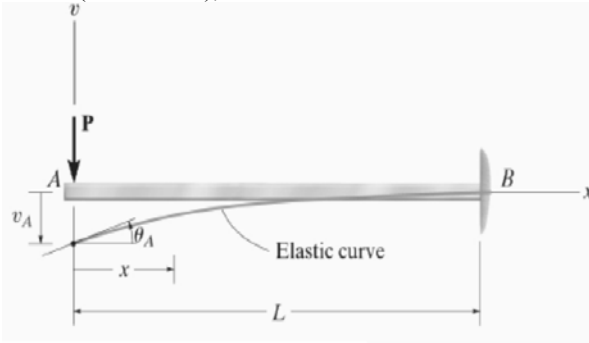


Figure 1. Cantilever beam under an end load P [1, p. 582].

The modulus of elasticity, which is a property of the beam, is presented in Table 1 for several materials. In Equation (1), “ I ” is a geometric property. For a beam with a rectangular cross-sectional area, it is defined as [4]:

$$I = \frac{1}{12}bh^3 \tag{2}$$

where b is the width of the beam (m), and h is the height of the beam (m).

Table 1. Modulus of elasticity of common structural material [4]			
Material	Steel A-36	Aluminum 6061-T6	Brass
Modulus of elasticity Pa (or N/m^2):	200×10^9	70×10^9	95×10^9

From Figure 1, the angle of deflection theta (θ_{max}) is defined as [4, p. 582]:

$$\theta_{max} = \frac{PL^2}{2EI} \quad (3)$$

where θ_{max} is measured at the end of the beam from the horizontal plane in radians.

EXPERIMENT

Three types of material were used (steel, aluminum, and brass) for the experiment. This experiment is not limited to the suggested beam materials; any elastic beam may be selected to perform the experiment. The experiment apparatus is presented in Fig. 2. It should be noted that the apparatus was designed and constructed by the senior author for under \$200.

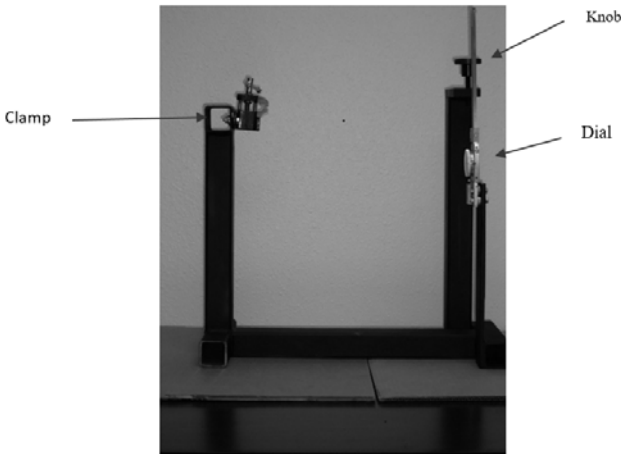


Figure 2. Experiment apparatus.

Utilizing the same beams, two experiments were performed. These two experiments are independent of each other and are described accordingly.

Beam Deflection with Known Weight

In this section, with a known mass, the deflection and the deflection angle are measured and analytically evaluated. The procedure to perform this part follows:

1. A steel beam from Table 1 was selected.
2. The beam was placed (the end without the hole) horizontally into the clamp, and the clamp was tightened.
3. The dimensions shown in Fig. 3 (length (L), width (b), and height (h)) were measured and recorded in Table 2. The measurements were taken three times, and the average values were used for the final calculations. Note that “ L ” was measured from the center of the hole to the edge of the clamp.
4. Masses were added to the free end of the beam to have approximately 0.5 inches of deflection. The total mass (m) was then recorded in Table 3. This task was performed three times, and the average value was used for the final calculations.
5. The deflection angle (in degrees) was measured using a protractor. See Fig. 1 for definition of deflection angle (θ). This task was performed three times, and the average value was used for the final calculations.

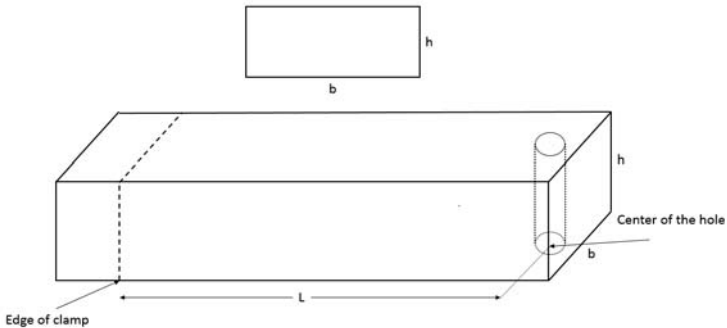


Figure 3. Beam dimensions.

Table 2. Beam material, property, and dimension measurements			
Trail	Material: Steel beam		Modulus of elasticity (N/m^2)
	L (m)	b (m)	h (m)
1	0.291	0.00255	0.0031
2	0.289	0.00256	0.0030
3	0.290	0.00255	0.0030
Average	0.290	0.00255	0.0030

Trial	Total mass (kg)	Deflection (m)	Deflection angle (°)
1	2	0.01346	5.5
2	2	0.01348	5.0
3	2	0.0345	5.0
Average	2	0.01346	5.17

Analytical Approach (I)

Beam deflection with known weight utilizing the integration method is presented in this section. These steps include:

- The average area moment of inertia using Equation (2) was evaluated using average measurements from Table 2. The result is recorded in Table 4.
- The total weight or force (w or P) were evaluated using

$$P=w=mg \quad (4)$$

where P (or w) is the weight or load (Newton), m is mass (kg), and g is the gravitational acceleration of earth (9.81 m/s^2). The result is recorded in Table 4.

6. The end deflection (v_A) was calculated using Equation (1). In this calculation, the weight (P) evaluated in step (b) of the calculation was used. The result is recorded in Table 4.
7. The θ_{max} (at the free end of the beam) in radians was calculated using Equation (3). The result is recorded in Table 4.

Results	Moment of inertia (m4)	Weight (N)	Deflection v_A (m)	Deflection angle, θ_{max} (°)
Analytical	5.737×10^{-11}	19.62	0.0139	4.12
Experimental	NA	19.62	0.01346	5.17
Error	-	-	3.17%	20.3%

Results/Analysis (I)

The experiment performed as expected with the beam undergoing a small deflection and returning to its original shape without any permanent deformation. It can be seen in Table 4 that the percent error for the deflection v_A is 3.17%. The percent error for the deflection angle is 20.3%. This relatively low error shows the accuracy of the inexpensive apparatus, while also proving the theory of beam deflection under the stated assumptions. The large discrepancy seen in the deflection

angle is largely due to the inaccuracy of the chosen measuring apparatus (protractor). As a beam bends, a curve is formed along the surface of the beam. Because of the lack of linearity of the curve and fact that it is a relatively small curve compared to the protractor used the angle was not able to be accurately measured. Further sources of error are discussed in the “Sources of Error” sections of this paper.

Beam Deflection with Unknown Weight/Force

In this section, with the known deflection and deflection angle, the unknown force is evaluated. The procedure to perform this experiment - is as follows:

- The same beam from part (I) was selected for this section of the experiment. Table 2 presents the dimensions.
- The micro adjustment screw was turned clockwise (CW) until the distance between the eyebolt and scriber (Figure 4) is 0.5 inch (0.0127 m). The final deflection was recorded in Table 5. As before, this process was performed three times, and the average value was used in the calculation.
- The deflection angle (in degree), utilizing a protractor, was measured and recorded in Table 5. See Fig. 1 for definition of deflection angle (θ). This task was performed two more times, and the average value was used for the final calculations.

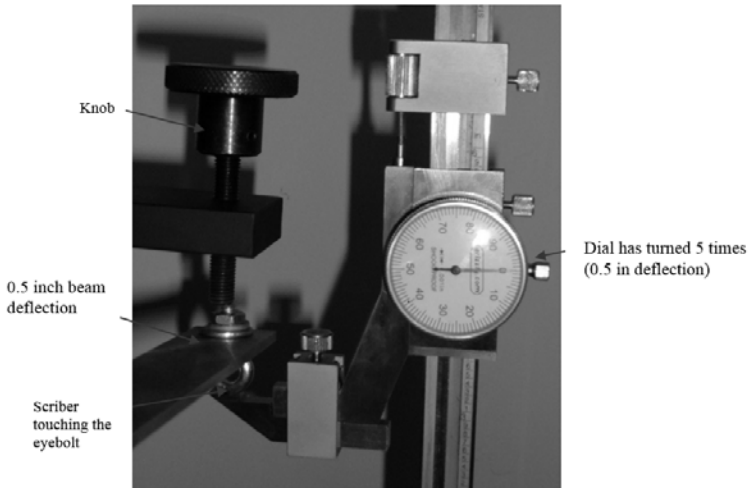


Figure 4. Unknown force causing 0.5-inch deflection.

Table 5. Measured behavior of the beam under load P		
Trial	Deflection (m)	Deflection angle (°)
1	0.0127 (0.5 in.)	5
2	0.0127 (0.5 in.)	5
3	0.0127 (0.5 in.)	5
Average values:	0.0127 (0.5 in.)	5

Analytical Approach (II)

- Using the deflection of 0.5 inch (1.27 cm), the E value from Table 1, and the average I value from Table 4, calculate the average end load (P) using Equation (1). The result is presented in Table 6.
- Using the measured average deflection angle from Table 5, the average end load using Equation (3) is calculated and presented in Table 6.

Table 6. Calculated values of moment of inertia and loads			
	Load calculation using Equation (1) (N)	Load calculation using Equation (3) (N)	Error
Results	17.92	23.8	33.4%

Results/Analysis (II)

The experiment performed as expected with the beam undergoing a small deflection and returning to its original shape without any permanent deformation. This experiment seems to have a very large source of error of 33.4%, because of the chosen way of measuring the deflection angle. The deflection angle was then used in Equation (3) to calculate the applied load. This caused the error from the measuring to propagate into the analytical phase of the experiments. The applied load was not experimentally measured because the purpose of this section was to give a comparison to the two similar equations, Equations (1) and (3).

SOURCES OF ERROR

When performing experiments, there will always be some errors. Sources of error might result from one or more of the following:

- Specimen fabrication. A sample was fabricated on a humid, hot, and windy day. Then, the next sample was fabricated on a dry, cold, and calm day. Therefore, two identical samples may

have the same composition but behave differently if the fabrication was not identical.

- Specimen composition. When the material compositions of
- two batches of specimen are not identical, the discrepancy in composition may cause different behavior under the same load condition.
- Test method. When evaluating the same mechanical properties of a specimen, there may exist several methods, including bending, twisting, or shearing the specimen. Therefore, if the same method of testing is not performed, the results may be different.
- Operator bias. If two operators are performing the same test, the results may be different based on their measurement accuracy, the time spent to perform the test, etc.
- Calibration. If the instrument utilized to measure a mechanical property is not calibrated, the result may not be accurate.

A large source of error in this experiment is operator bias and test method. The experiment was performed by a human and may not have been executed as accurately as possible. The decision to use a protractor to measure the deflection angle was not the most accurate due to the curve of the bar as the load was applied. Because of the position of the angle that needed to be measured the protractor was inefficient at taking the measurement. Another source of error worth noting is the weights are not exactly as noted on the weight for example the weight claimed to be 100 g but was later weighted at about 99.1 g.

CONCLUSION

Throughout this paper, the theory of beam deflection has been explained and used. The equations presented and the experiments done prove the importance of knowing and understanding how beams act under a vertical load. It shows that as beams are deflected within the elastic limit they will return to their original shape without any permanent deformation. These fundamental principles are what have literally built our society—without the knowledge of beam deflection skyscrapers would not be possible and bridges would collapse. This experiment shows how simple it is to gain a basic understanding of the fundamentals of beam deflection on a relatively low budget.

ACKNOWLEDGMENTS

The funding was partially supported by the Engineering & Technology Department, and the Department of Workforce Services Grant

entitled “STEM Career Paths to Success.” This grant was awarded to Mr. Richard Cozzens (Professor of Engineering Technology at Southern Utah University) during the 2015-2016 academic year.

REFERENCES

- [1] Jenkins, D. (2008). The history of the theory of beam bending—Part 1. Retrieved July 20, 2015 from <https://newtonexcelbach.wordpress.com/2008/02/27/the-history-of-the-theory-of-beam-bending-part-1/>
- [2] Heyman, J. The Science of Structural Engineering, Imperial College Press, London, UK, 1999.
- [3] Timoshenko, P. History of Strength of Materials, McGraw-Hill, New York, 1953.
- [4] Hibbeler, R.C. Mechanics of Materials, 9th edition, Pearson Education, Upper Saddle River, NJ, 2014.

Fundamental Look at the Properties of Copper

Casey Cooper, Jacob Carter, Justin Christensen, and
Ali S. Siahpush

Southern Utah University

ABSTRACT

Copper has been used for centuries as a tool, religious symbol, and token of societal hierarchy. The use of copper has been mentioned in some of the oldest civilization records even as early as 9000 BC in the Middle East. Copper was the main element to bring civilization from the Stone Age into the Bronze Age. The physical, chemical, electrical, and magnetic properties have solidified copper's integral place in today's society. Its abundance, low extraction cost, and versatility make it an excellent material for electrical and thermal applications. The general properties of copper will be discussed throughout this paper, including physical, chemical, electrical, magnetic, optical, economic, environmental, and practical applications. The discussion of each of these properties will help to gain a broad understanding of copper. Some of the more in-depth topics will be on copper's electrical resistivity and its mechanical properties, in which experimental data was gathered representing some of the important properties of copper such as its ductility and its electrical conductivity. This paper also

describes in detail the various properties of copper that make it useful in our society. The research was performed in conjunction with laboratory exercises to provide a succinct piece on the history of copper and its uses.

A BRIEF HISTORY OF COPPER

Archaeological evidence shows that copper was one of the first metals utilized by humans. It was used at least 10,000 years ago for objects such as coins and trinkets in western Asia. During the prehistoric Chalcolithic Period (from the Greek word for copper, chalkos), man discovered how to mine and produce copper for use in tools and weapons. As early as 4000 BC, man extracted copper from Spain's Huelva region. The discovery of the process for alloying copper with tin to produce bronze led to the Bronze Age, around 2,500 BC. The Timna Valley in Israel provided copper to the Egyptians. Papyrus records have been found that illustrate the use of copper to treat infections and to sterilize water. The Greek island of Cyprus supplied much of the Phoenician, Greek, and Roman needs for copper. In fact, the name "copper" is derived from the Latin word Cyprium, literally meaning Cyprian metal. The Greeks of Aristotle's era were familiar with brass as a valued copper alloy for its strength and malleability. In South America, the pre-Columbian Maya, Aztec, and Inca civilizations made use of copper, in addition to gold and silver. During the Middle Ages, copper and bronze works flourished in China, India, and Japan. The discoveries and inventions relating to electricity and magnetism of the late 18th and early 19th centuries by scientists such as Ampere, Faraday, and Ohm, and the products manufactured from copper, helped launch the Industrial Revolution and propel copper into a new era. Today, copper continues to serve society's needs. Although copper has been in use for at least 10,000 years, innovative applications for copper are still being developed as evidenced by the development of the copper chip by the semiconductors industry [1].

THE ORIGINS

The source of all copper atoms is fusion processes in large supergiant stars [2]. Elements above iron in the periodic table are unable to form in typical nuclear fusion reactions in stars such as the sun. Copper is too heavy an element to form under these circumstances. It is only in much more energetic reactions such as those in supergiant stars undergoing a supernova explosion where heavier elements such as a copper atom form. This explosion also spreads the formed atoms across the

cosmos. This is what our earth formed out of, creating the natural supply of elements found. The mantle of the earth is made out of a liquid phase solution of many elements. When this mix of elements rises to the surface, it cools and the mix becomes concentrated as some elements solidify before others. This is how veins of concentrated copper form in the earth's crust [3]. These veins are then mined to create the industrial supply of copper that we use today.

PERIODIC TABLE

Copper appears on the periodic table in the transition metals in group 11 in the “d” block. Copper has an atomic number of 29 and under normal circumstances has an electron configuration of [AR] 3d¹⁰ 4s¹. Usually, the transition metals are known for having a partially filled d subshell [4]. Copper, however, has a full d subshell but a partially filled s subshell. This happens because of quantum mechanical effects that allow copper to be more stable this way. Copper also has a few different ions but the most common of the ions is copper (II); copper (I) also appears but often copper (I) will turn into copper (II) in nature. Copper (II) has lost four electrons to become more positively charged and is often bonded with oxygen to make copper oxide. Copper (II) is also known as cupric [4].

ATOMIC STRUCTURE

Copper is a crystalline solid, meaning that it will repeat the same structure repeatedly as it bonds with itself. The lattice structure of a basic copper atom is face centered cubic (FCC). This means there are 6 half atoms at each face and 1/8th of an atom in each corner [5]. The total number of atoms in the lattice structure is 4. The atomic radius, R , is used to determine the length of the lattice structure, a . The length of the lattice structure is most commonly used in density calculations. The calculation of lattice length is shown as

$$a = 2R * \sqrt{2} \quad (1)$$

A simple laboratory exercise was conducted to visually analyze the relationship of the atoms and lattice structure length by constructing a scaled FCC model of gumdrop structures, as shown in Figure 1. The atomic radius of copper was used to appropriately scale the sides of the lattice to a correct shape.



Figure 1. FCC structure of copper atom.

PROPERTIES

Mechanical Properties

The general mechanical properties of copper are defined as the yield and ultimate strengths, ductility, hardness, impact resistance, and fracture toughness. Copper is a soft metal and has a low hardness. It is naturally soft because of its structural configuration. Copper forms metallic bonds that have a sea of electrons sharing all of the excess or valence electrons with other copper atoms. Because of the natural way copper forms bonds, it has a low bond strength, making it easier to break those bonds and reform them. This, in essence, is ductility or the ability of copper to stretch without breaking to a certain limit.

In experiments at the Southern Utah University Engineering Department, a copper specimen was placed in an Instron tensile testing machine as seen in Figure 2. This machine was used to apply a tensile load to the copper specimen. Because of the incremental tensile force, the stress vs. strain relationship was evaluated (Figure 3). This figure presents several mechanical properties of copper. It can be observed from Figure 3 that the yield strength of copper is experimentally evaluated to be 35.5 ksi and the ultimate stress is 39.05 ksi with a maximum percent elongation of 43.87 % at failure. In summary, copper is a naturally soft metal and works excellently for implementations like copper tubing in plumbing or electrical wires in which ductility has a distinct advantage. [6]

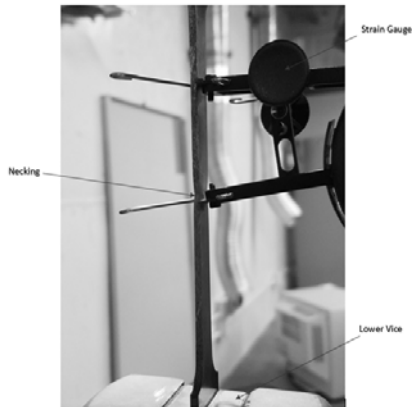


Figure 2. A specimen of copper placed in the Instron machine during a tensile test.

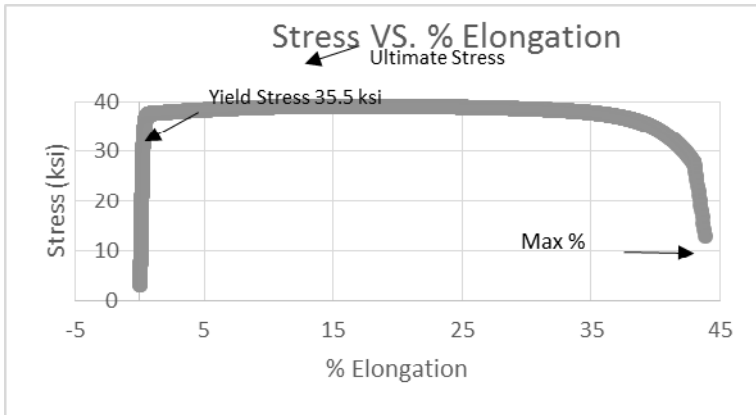


Figure 3. Graph of stress vs strain of non-annealed copper under a tensile load to failure.

Chemical Properties

Metals experience corrosion when their composition is altered by a chemical reaction. Copper is slightly inert, which means it is not very susceptible to corrosion. In the case of oxidation, copper forms a protective layer on the surface when exposed to water and oxygen. This protective layer, patina, is similar to the passivity layer, which other metals form. Patina is greenish in color, which can be seen on the

Statue of Liberty [7]. Originally, the Statue of Liberty was a rose-gold colored copper tone, but it has since become covered in patina, as shown in Figure 4. This protective response to corrosion makes copper a viable roofing material.



Figure 4. Original copper color of the Statue of Liberty [8].

Biological Effects

Copper is an essential part of a healthy diet and is vital for life. It helps the body maintain healthy skin, brain functions, and heart health. It aids in the development of babies during pregnancy. It can also help in the healing of wounds. Many foods contain copper, including shellfish, leafy greens, nuts, meat, dark chocolate, fruit, mushrooms, beans, avocado, and goat cheese. A deficiency of copper can lead to conditions such as anemia, heart disease, osteoporosis, and arthritis. It is then very important to get the minimum recommended amount of copper intake of 900 mcg per day [9].

Copper Alloys

The two most common alloys of copper are brass and bronze. Brass is an alloy of copper with zinc used as the predominant impurity. When a brass specimen contains zinc percentages higher than 39%, the strength increases while the ductility decreases. A common application

of brass is ammunition casings. Bronze can be made with the impurities aluminum, silicon, tin, or nickel. These impurities increase the ductility, which makes bronze ideal for sculpting and artwork.

Annealing

Annealing is a procedure in which a metal is heated for a length of time. This heating allows internal stresses in the material to be released that usually allows the material to become more ductile and reduces the yield stress and ultimate stress. Copper is already an extremely ductile metal, and after annealing, it is even more so. An experiment was conducted to measure the effects of annealing on copper's ductility, strength, and hardness. A summary of the results will be included in this report and the laboratory report detailing the procedures and process is available per request from the lead author of this paper.

As is shown in Figure 5, if copper is heated to half of its melting temperature for 40 minutes, it will become more ductile than it had originally been. The yield stress and ultimate stress were decreased dramatically. It was also observed that the annealed copper had an overall change in length of 1.63" and the nonannealed copper had an overall change in length of 0.935".

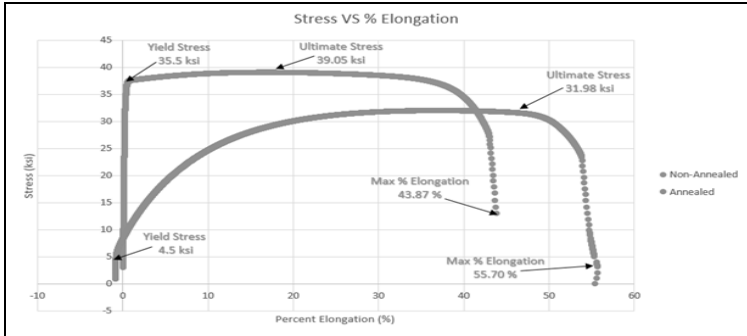


Figure 5. Graphical comparison of the annealed (lower right curve) and the nonannealed copper (upper left curve).

Electrical Resistivity

The ultimate use of copper is in electrical applications because it is highly conductive. Electrical conductivity is a material's ability to transfer electrical energy. Copper is a good conductor because it forms metallic bonds, which are essentially an electron cloud. This type of bond makes it easier to transfer energy.

The resistivity, which is the inverse of conductivity, describes a material's inability to conduct electric current. The resistance, R , cross-sectional area, A , and length, l , can be used to determine the resistivity as

$$\rho = \frac{R * A}{L} \quad (2)$$

Copper typically has low resistivity, but a laboratory experiment was conducted to test the change in resistivity with changing temperatures in a 50-cm length of 14 Ga copper wire. The resistance was tested at five temperatures: -34°C, 0°C, 18°C, 100°C, and 200°C. A constant current was passed through the wire, and the voltage was measured using a multimeter. The current, I , and voltage, V , were used to derive the resistance.

$$V = I * R \quad (3)$$

The laboratory results are shown in Table 1. Figure 6 reveals that the resistivity increases with increasing temperature. A slight discrepancy can be seen between experimental values and reference values, but this can be attributed to equipment with insufficient measuring capabilities and the small amount of data points collected. The resistivity increases with temperature because the heat energy applied to the wire causes electrons in the copper atoms to become excited into the electron cloud. The increase in electrons in the electron cloud creates interference, which makes it more difficult for the current to pass through the wire.

Temp Tested (°C)	Found Resistivity (Ω*m)	Reference Resistivity (Ω*m)	Percent difference
-38	1.52E-08	1.26E-08	-21%
0	1.67E-08	1.49E-08	-12%
18	1.73E-08	1.60E-08	-8%
100	2.04E-08	2.11E-08	3%
200	2.29E-08	2.73E-08	16%

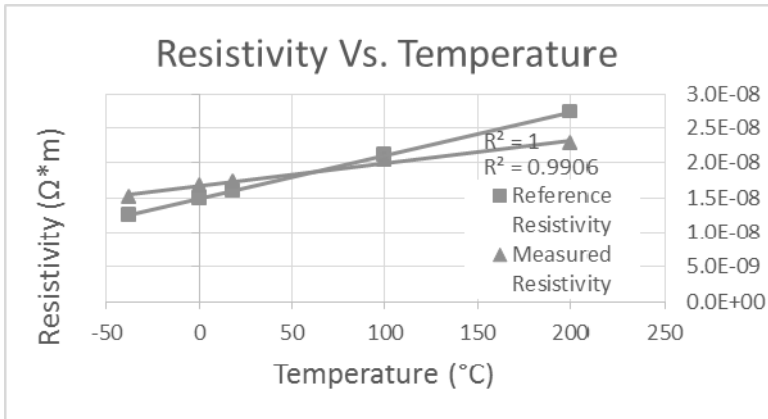


Figure 6. Experimental resistivity vs. reference resistivity.

Thermal Properties

Copper has some excellent thermal properties that make it ideal to use as heat sinks and radiators. The thermal conductivity of copper comes from its sea of electrons. Copper has two valence electrons that are free to move about from one copper atom to another copper atom [4]. This allows copper to pass energy rather quickly. The passing of energy comes from physical contact. As the electrons run into one another, they pass energy, which copper does very well. Figure 7 shows that as copper increases in temperature its thermal conductivity goes down. At first, an increase is observed, but then it will rapidly start to drop off. This effect is due to the sea of electrons. You can think of it like table soccer; the more people on the “field,” the harder it is for the ball to move from one end to the other. When there is just the right number of players on the field, you will run into them and pass the energy on, but when the small field is packed full, you now have more interference than you have the actual passing of energy. The same thing happens as copper heats up. At first, its movement of energy increases and then eventually it reaches a point where chaos reigns and becomes more of an interference than a help.

As energy flows through the material, the atoms become excited and expand the radius of orbiting electrons resulting in an actual measurable change in the size of the copper bar. The coefficient of thermal expansion of copper is

$$17 * 10^{-6} \left(\frac{1}{^{\circ}\text{C}} \right).$$

This coefficient of expansion is a measurement of the volumetric change in size per °C. To understand the use of the thermal expansion, Eq. (4) is given, where ΔL is the change in length, L is the original length, ϵ is the change in length over the length, α is the coefficient of thermal expansion, and ΔT is the change in temperature.

$$\frac{\Delta L}{L} = \epsilon = \alpha \Delta T \quad (4)$$

This equation helps us understand how much copper will expand with the change in temperature. From here the equation can then be connected to things in design applications. Imagine if a train track is designed without considering the expansion of steel as it heats up. The end result will be buckling of the track as it will expand and have no place to go but to bend. Copper is a metal and will expand as it heats up, and this will need to be considered if it is to be used under large temperature changes [10].

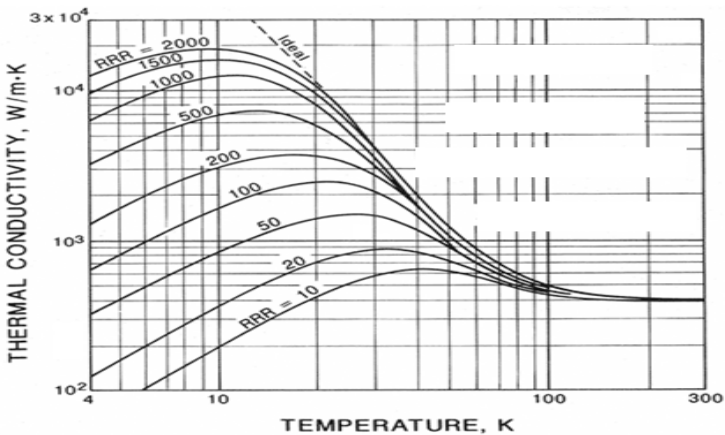


Figure 7. Thermal conductivity of copper [4].

Uses for Copper

Because of copper's excellent conductivity of thermal and electrical energy, it has many applications. The most common application, with 60% of industrial consumption, is in electronics and electrical wire. The next most common usage is in roofing and plumbing, with 20% of total copper consumption. Copper is great for these purposes because of its corrosion properties. Copper accumulates a patina layer,

which slows corrosion considerably. It is also useful in plumbing for its thermal conductance for heat sinks and radiators. Usage in industrial machinery makes up 15% of copper's total consumption. The final 5% of copper usage is in making alloys such as brass and bronze [4].

Fabrication

The fabrication of copper is an old art form that has been refined over millennia. There are many ways to work with copper, and in the beginning, they did a lot of smelting or the melting down of copper and then using a mold of sand or clay to form the copper [4]. Types of fabrication include hot work, cold work, forging, rolling, extruding, casting, welding, and machining. Because copper is a relatively soft metal, it is easy to work, making it a prime metal to use in most fabrication techniques. The desired mechanical properties and functionality will determine the way to fabricate the copper. Even after copper has been formed, it is still vulnerable to physical damage or chemical damage. To prevent damage, copper should be stored properly based upon its later application.

Economics and Environment

When you consider the cost to benefit ratio of copper, it is an extremely economical material. Other materials with similar properties as copper, such as silver, are very expensive to produce or not as common, which increases the cost of those materials [12]. As discussed, copper has excellent thermal and electrical properties, which make it great for the use in wires, plumbing, and heat sink applications. There is an incredible amount of electronics use in our current world. All of these electronics—whether it is wire or motherboards or heat sinks—use a lot of copper. If all of that copper was replaced with silver, the cost of a cell phone would be tremendously more. Similarly, in welding applications, the welding leads are copper wires and they are usually hundreds of feet long. The efficiency of copper with its relatively low cost of production and its abundance make it an amazingly economical material. Although some metals become toxic when left in scrapyards, copper and its alloys do not. It is considered biodegradable because it can wear down over long periods of time. Pure copper can be recycled to use in the production of superfine enameled wires [4]. The purity requirements for power cables are slightly less than those of enameled wires, so more recycled copper may be used in this application. Other applications that do not require high conductivity, such as plumbing tubes and roofing sheets, will recycle less pure specimens of copper.

CONCLUSION

In summary, copper is an important element of nature and humankind. It has many unique properties that distinguish it among the other metals and prove its usefulness. Its abundance in nature and its recyclability create a large supply and cheap production cost. Its conductance of thermal and electrical energy makes it a staple in modern electronics and thermal applications. The ductility makes it easier to be worked and machined and also allows it to be used in many applications, such as wires, where high elasticity is desired. The slow corrosion makes it useful in many environments in which it needs to maintain structural integrity. In addition to modern usage, copper has been an icon for mankind's progression and domestication of nature. It has held reverence in many cultures because of its accessibility, workability, and brilliant appearance. In short, it is an important material in past, present, and future.

REFERENCES

- [1] Dartmouth Toxic Metals Superfund Research Program. (2010). Copper: An ancient metal. Retrieved November 18, 2016 from <http://www.dartmouth.edu/~toxmetal/toxic-metals/more-metals/copper-history.html>
- [2] Chaisson, E. and McMillan, S. (1999). *Astronomy Today* (3rd ed.) New York, Prentice-Hall. Ch 21
- [3] Reynolds, Stephen J. (2002). Formation of a Porphyry Copper Deposit. Retrieved November 18, 2016 from http://reynolds.asu.edu/sierra_cobre/p_formation.htm
- [4] Emsley, J. (2001). *Nature's Building Blocks: An A-Z Guide to the Elements* (2nd ed.) Oxford, Oxford University Press.
- [5] Callister, W. D., and Rethwisch, D. G. (2013). *Materials Science and Engineering* (9th ed.) Hoboken, NJ, Wiley.
- [6] Dissemination of IT for the Promotion of Materials Science. (2004). Introduction to Mechanical Testing. Retrieved November 26, 2016 from <http://www.doitpoms.ac.uk/tlplib/mechanical-testing/index.php>

- [7] Thompson, A. (February 9, 2013). Why Does Copper Turn Green? Retrieved November 22, 2016 from <http://www.livescience.com/32487-why-does-copper-turn-green.html>
- [8] Currier & Ives. (1885). The Great Bartholdi Statue, Liberty Enlightening the World: The Gift of France to the American People. Retrieved December 15, 2017 from https://en.wikipedia.org/wiki/File:Currier_and_Ives_Liberty2.jpg.
- [9] Ehrlich, S. D. (January 2, 2015). Copper. Retrieved November 22, 2016 from <http://umm.edu/health/medical/altmed/supplement/copper>
- [10] Davis, J. (2008). Copper and copper alloys. Materials Park, OH, ASM International.

Effect of Different Potential Combinations on Characteristics of Nanoparticles formed by Dewetting

T. McKay Stoker and Nick A. Roberts
Utah State University

Abstract

Dewetting (the contraction of a thin film into droplets on a substrate) may be used to self-assemble nanoparticles. Understanding how to direct the assembly of nanoparticles from dewetting is critical to effective application of the method. In previous work, it was found that adding a capping layer over the film alters the final morphology of nanoparticles. Choosing cap and substrate substances that have certain potentials with the film is a possible technique to control dewetting. We studied the effect of changing these potentials in various combinations with the aid of molecular dynamics (MD) simulations. The size and characteristics of the nanoparticles formed were analyzed. We found that the higher energy surface, whether the substrate or cap, dominates dewetting. We also found that the higher energy potentials caused smaller nanoparticles to form or even to keep the film wet to the surface.

Introduction

Nanoparticles on a surface have a variety of applications. These include, but are not limited to, chemical and light sensors, chemical reaction catalysis, photonics, and communication systems. Many applications benefit from nanoparticles having high surface area-to-volume ratio, being in close proximity to other nanoparticles, and having a well-defined and uniform size.

Techniques for creating these structures vary and have various individual advantages. Fabrication procedures that achieve any considerable level of accuracy are often time and resource intensive. Direct-write nanofabrication [1-3] is a state-of-the-art process that allows for ultimate resolution and three-dimensional patterning. However, along with being time and resource intensive, this technique also deposits impurities in structures because of the chemical radicals required for deposition.

Directed self-assembly provides a possible lower-cost method of nanofabrication. A phenomenon known as dewetting is a possible candidate to control nanoparticle distributions via self-assembly. Dewetting is the process of a film on a surface rupturing to form droplets. Stimulating dewetting requires simply adding energy to the system, such as by a hot plate or a pulsed laser. Many studies, including the work of Fuentes-Cabrera *et al.* [4], have been done on controlling the phenomenon of dewetting for directed self-assembly. A study performed by White [5] explored the effects of a capping layer on the final morphology of nanoparticles formed by dewetting gold and nickel films. That study showed opposing trends for nickel and gold. Nickel nanoparticles became smaller with a cap while gold nanoparticles grew with a cap.

The current work focuses on the strength of the interactions of the film with both substrate and cap. We are studying the effects of varying these parameters on the nanoparticles formed. The goal is to identify trends and driving factors to inform choice of substrate, film, and/or capping layer based on design constraints for a specific application. Molecular dynamics (MD) simulation is utilized to study these effects. It provides a relatively quick and inexpensive method that can give insight into the process.

Methodology

MD simulations are performed using the large-scale atomic/molecular massively parallel simulator (LAMMPS), a classical MD code provided by Sandia National Laboratory [6]. Silica (SiO_2) is chosen as the substrate, gold (Au) as the film, and alumina (Al_2O_3) as

the capping layer. These material choices were based on the experimental work of White [5]. The silica is formed using its quartz lattice [7]. Alumina is formed with its sapphire structure [8]. Gold is the simplest to form as it has a basic face-centered cubic (FCC) lattice. The silica substrate dimensions are $310 \times 310 \text{ \AA}$ with a thickness of 5.405 \AA , which is one silica unit cell thick. The gold layer is placed 3.546 \AA above the substrate. The separation is used to prevent violent starting behavior from atoms being placed too close. The gold film is $306 \times 306 \text{ \AA}$ with a thickness of 4.080 \AA , the thickness of one gold unit cell. The alumina cap is placed above the gold with the same 3.546 \AA offset. The alumina cap dimensions are identical to those of the silica substrate. Figure 1 shows a schematic of the system domain.

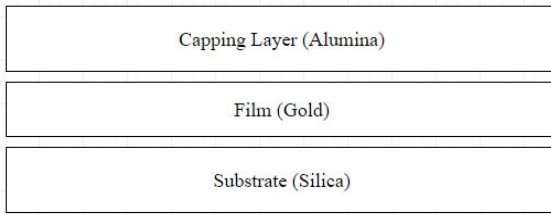


Figure 1: Basic system diagram

The force fields for each layer are well known and have been published in forms compatible with LAMMPS. The interactions between atoms in the substrate are described with a Tersoff potential [7]. Gold to gold interactions are described with an embedded atom method (EAM) potential [9]. Interactions within the capping layer are defined by a kind of EAM potential modified for alloys [8]. The alumina and gold potentials are included with the LAMMPS software package.

The potentials between atoms in different layers are not as established and provide the variable for this study. Other than the in-layer potentials described previously, all other atom interactions are described using a Lennard Jones (LJ) potential. The LJ potential style uses a relatively simple calculation of atom interaction energy. It requires two parameters: an energy constant that describes the depth of the potential well and the corresponding magnitude of interaction energy (ϵ), and a distance constant that describes the weakening of interaction energy as atoms become further apart (σ). As our focus is on the effect of substrate and capping layer interactions with the film, the ϵ between silica and alumina atoms is set to 0.00028 electron-Volts (eV), a comparatively low value, to minimize the effect of their interactions on the dynamics of the simulation. The ϵ for interactions of substrate

atoms and gold atoms and the ϵ for interactions of capping layer and gold atoms are changed in different combinations for each simulation. Table 1 details the ϵ values used, which were obtained from Fuentes-Cabrera *et al.* [4]. The σ for each interaction was also obtained from Cabrera *et al.* [4], although they are not the focus of this study. Note that because the LJ parameters are arbitrary and not based on the actual materials in the system, the simulations do not accurately depict a SiO₂-Au-Al₂O₃ dewetting system. Rather, the simulations provide means for study of how dewetting characteristics change with interaction energy.

Table 1: Energy parameter (ϵ) values used for LJ potentials in MD simulations	
ϵ_L (L)	0.086092 eV
ϵ_M (M)	0.17240 eV
ϵ_H (H)	0.25895 eV

Simulations are run both with and without a capping layer. Only one simulation is run with no cap, using ϵ_L for silica-gold interaction. The results from this simulation are compared with those from the capped simulation with ϵ_L at both surfaces to see the effects of a cap. Nine simulations are run with a cap to account for all combinations of silica-gold and alumina-gold interaction energies. The values of ϵ for these simulations will be referred to by two-letter acronyms, with the silica-gold ϵ coming first. For example, the simulation using ϵ_M for the silica-gold potential and ϵ_H for the alumina-gold potential is the MH simulation.

Each simulation has a few fixes applied. A fix is an integration scheme that LAMMPS uses to update various quantities, such as position and velocity, associated with each atom. An NPT fix (constant number of atoms, constant pressure, and constant temperature) is applied to the gold film where the temperature and pressure are held constant to 1400 K and 0 bar, respectively. The substrate and cap are not included in this fix as the dewetting of the gold film is the focus of the simulation. The substrate and cap atoms are assumed to remain in their original lattice positions. To be complete, fixes imitating gravity are applied to the film and capping layer.

LAMMPS has the option to produce images of the simulations at various time steps. We produce a grayscale image for each simulation at its last time step. This image is taken from the top of the system. The grayscale image only includes the gold atoms. This permits a clear view of the dewet nanoparticles. An example set of images that demonstrate the time evolution of the dewetting process are shown in Figure

2. These images are then processed through a nanoparticle analyzer code for MATLAB [10]. The code extracts nanoparticle (NP) radius (our NP size parameter) and spacing data via image processing techniques. Our focus will be the size data; we will not discuss the spacing data in this study.

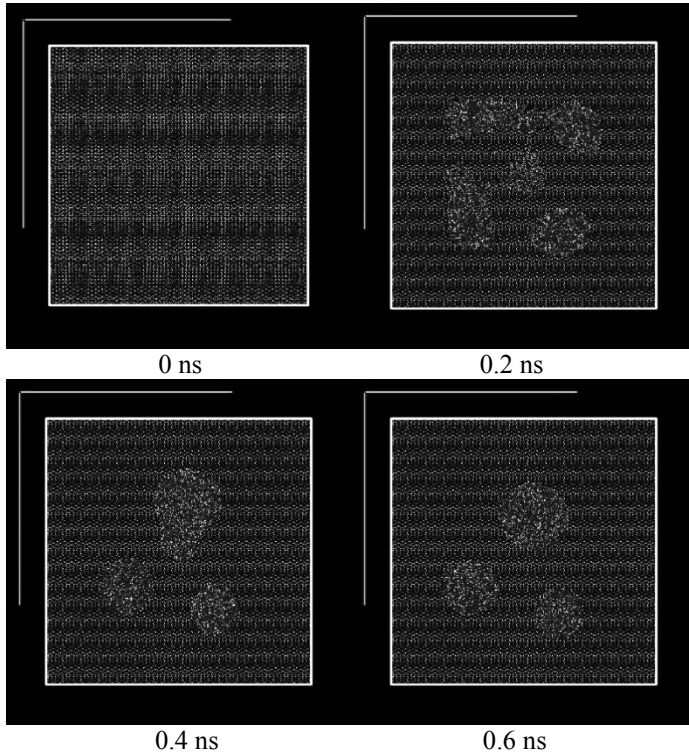


Figure 2: Time progression of a thin film (blue atoms) dewetting on a substrate

Some simulations produce several “xyz” files containing position data for the gold atoms for use in a molecular visualization program. The visualization software RasMol [11] is used to study the final morphology of the gold nanoparticles. Qualitative understanding of the dewetting process and mechanisms is thus extracted.

Comparison of results from all 10 simulations exposes effects of different potential combinations, as well as effects of the capping layer. The data also shows the possibilities and processes of using dewetting as a directed self-assembly method.

Results and Discussion

L vs LL

The results of the uncapped L and the LL simulations are fundamentally different. This agrees with the finding of White [5] that the cap alters the size and distribution of the dewet nanoparticles. See Figure 3 for a comparison of images from both simulations. Although both simulations involve only ϵ_L , the cap causes the nanoparticles in the LL simulation to evolve unlike those in the L simulation.

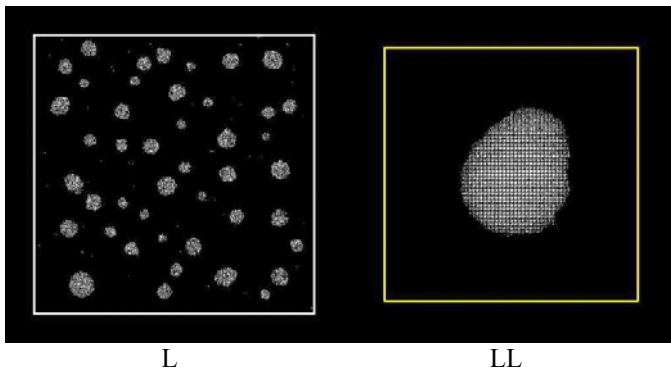


Figure 3: Comparison of L and LL images

H Potentials

When the ϵ_H interaction was involved, either from the substrate or the cap, very little dewetting occurred. The atoms mostly stayed separate, and few particles were formed because of the surface energy remaining near equilibrium. There was so little dewetting that the nanoparticle analyzer program could not accurately detect the few particles there were. For this reason, we will not include any size data for simulations involving the ϵ_H interaction.

Perhaps the nanoparticles need more time to develop with higher energy interaction. To test this hypothesis, we ran the final simulation, HM, for 30 ns, while other simulations were run for 10 ns at most. (See Figure 2 for the general time evolution of a dewetting film.) Again, however, there were few particles in the resulting image. The H interaction energy forces the gold atoms to stay mostly wet (i.e., remain a continuous film). Further the gold atoms stay wet to the surface that has the ϵ_H interaction.

Interesting findings were made when LH was compared with HL and MH was compared with HM. While HL and HM show no visible particles, LH and MH both have distinct particles in their pictures. See Figures 4 and 5 for images showing the final state of these simulations. This seems to suggest that the film dewets on the cap with ϵ_H but not on the substrate with ϵ_H . Using RasMol, we investigated the xyz files for HM and MH. This showed the same result as the pictures. The MH simulation truly had formed distinct nanoparticles while the HM simulation had not. The reason for this difference is not apparent.

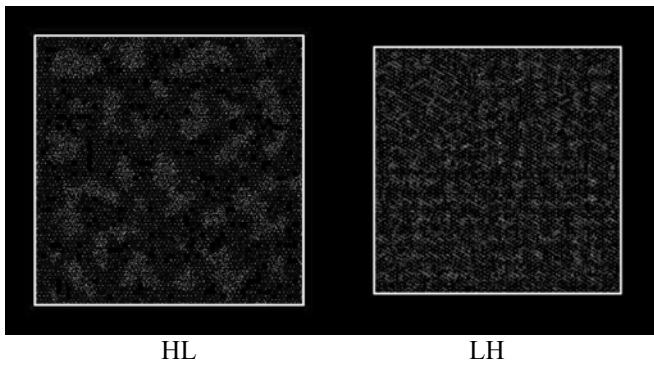


Figure 4: Comparison of HL and LH grayscale images

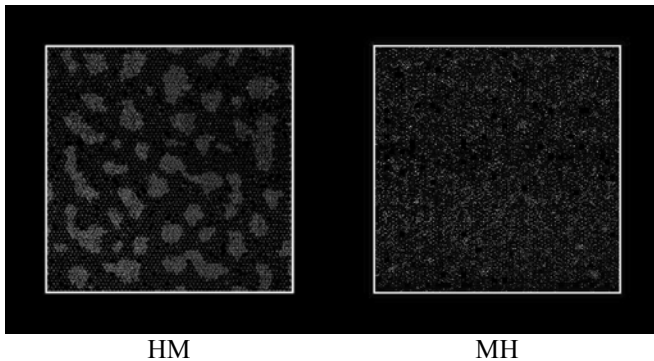


Figure 5: Comparison of HM and MH grayscale images

L & M Potentials

The nanoparticle analyzer could much more accurately capture the particles of the lower energy simulations. The LL, LM, ML, and

MM simulations were all analyzed for NP size. See Figure 6 for NP size distributions from these simulations. Since LAMMPS produced images with a perfectly black background, a lower threshold value could be used for image processing. A lower value also increased the program's ability to find the nanoparticles in the picture. We found a threshold of one, from the grayscale intensity range of 0:255, to produce the best results. This was used consistently for analyzing the pictures from each simulation.

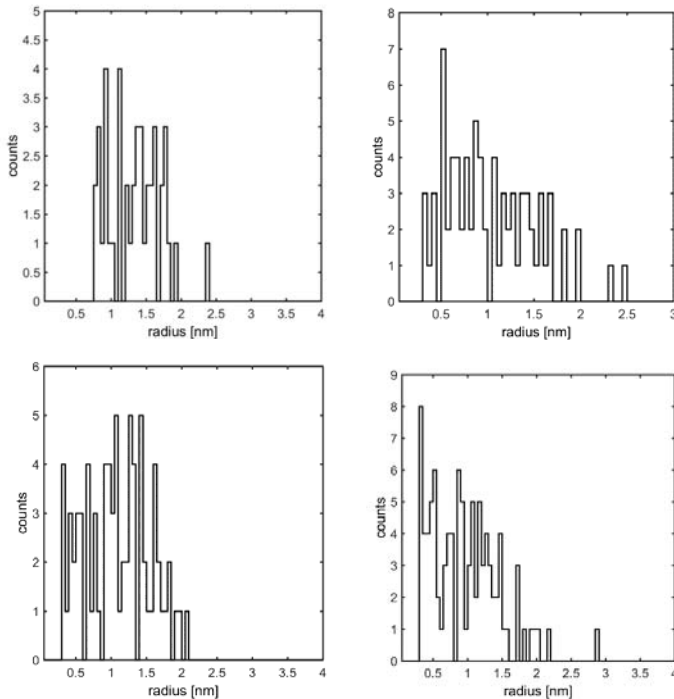


Figure 6: (Top left) LL NP size distribution; (top right) LM NP size distribution; (bottom left) ML NP size distribution; (bottom right) MM NP size distribution.

The nanoparticle analyzer would sometimes erroneously extrapolate a pixel (an atom) into a particle. Any nanoparticle smaller than 0.5 nm was likely to have been extrapolated from a single atom. To condition the data prior to finding average NP sizes, all size data points less than 0.5 nm were removed. Table 2 shows the average particle radius and standard deviation for LL, LM, ML, and MM. Note that the distri-

butions of Figure 6 were made prior to conditioning the data and therefore still have the erroneous data points.

Table 2: Nanoparticle size data for the four L and M combination simulations		
	Average NP radius (nm)	Standard deviation (nm)
LL	1.31	0.372
LM	1.12	0.443
ML	1.17	0.392
MM	1.13	0.431

As Table 2 shows, LL had the largest average NP size. The simulations with an M interaction produced generally smaller particles. This agrees with the principle that the higher the interaction energy is, the more the atoms energetically favor sticking to the surface rather than to each other. The simulations with an M interaction also have broader size distributions, shown by their standard deviations.

Each of the bottom three averages are not significantly different from each other. It seems that the higher energy surface dominates the dewetting, whether it is M or H. The highest interaction energy dictates the dewetting behavior. Using RasMol, the LM simulation xyz file shows the gold atoms clinging to the alumina cap, the higher energy surface (Figure 7).

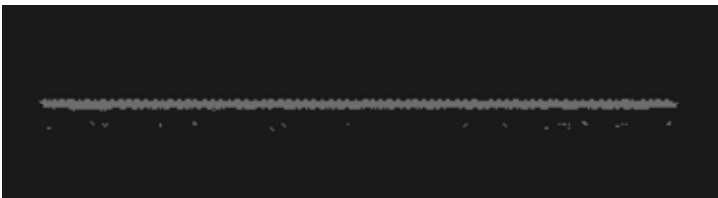


Figure 7: Side view of LM simulation from RasMol.

Conclusion

Increasing the interaction energy of the cap or the substrate makes the average NP size smaller but broadens the particle distribution. This agrees with the findings of White [5]. Also, the higher energy surface dominates the dewetting and the nanoparticles form at that surface. This permits choice of whether the nanoparticles form on the cap or substrate by choosing which surface has the higher energy. These re-

sults allow us to conclude that NP distributions may be changed by altering the potentials via material selection. These findings are positive steps toward using dewetting for directed self-assembly. However, more research is needed before dewetting can be effectively used for nanoparticle fabrication.

Acknowledgments

Financial support for this project was provided by the Engineering Undergraduate Research Program (EURP) Grant through the College of Engineering at Utah State University.

References

- [1] J. A. Spencer *et al.*, “Understanding the electron-stimulated surface reactions of organometallic complexes to enable design of precursors for electron beam-induced deposition,” *Applied Physics A*, vol. 117, pp. 1631-1644, Dec. 2014
- [2] A. Botman, J. J. L. Mulders, and C. W. Hagen, “Creating pure nanostructures from electron-beam-induced deposition using purification techniques: a technology perspective,” *Nanotechnology*, vol. 20, p. 372001, Sep. 2009
- [3] S. Jesse *et al.*, “Directing matter: toward atomic-scale 3D nanofabrication,” *ACS Nano*, vol. 10, pp. 5600-5618, May 2016
- [4] M. Fuentes-Cabrera *et al.*, “Molecular dynamics study of the dewetting of copper on graphite and graphene: implications for nanoscale self-assembly,” *Physical Review E*, vol. 83, p. 41603, Apr. 2011
- [5] B. C. White, “Investigating the effect of capping layers on final thin film morphology after a dewetting process,” M.S. thesis, Dept. Mech. and Aerospace Eng., Utah State University, Logan, UT, 2016
- [6] S. Plimpton, “Fast parallel algorithms for short-range molecular dynamics,” *Journal of Computational Physics*, vol. 117, pp. 1-19, Mar. 1995

- [7] S. Munetoh *et al.*, “Interatomic potential for Si-O systems using Tersoff parameterization,” *Computational Material Science*, vol. 39, pp. 334-339, Apr. 2007
- [8] F. H. Streitz and J. W. Mintmire, “Electrostatic potentials for metal-oxide surfaces and interfaces,” *Physical Review B*, vol. 50, pp. 11,996-12,003, Oct. 1994
- [9] S. M. Foiles, M. I. Baskes, and M. S. Daw, “Embedded-atom-method functions for the FCC Metals Cu, Ag, Au, Ni, Pd, Pt, and their alloys,” *Physical Review B*, vol. 33, pp. 7983-7991, Jun. 1986
- [10] J. D. Fowlkes *et al.*, “Parallel assembly of particles and wires on substrates by dictating instability evolution in liquid metal films,” *Nanoscale*, vol. 4, pp. 7376-7382, Sep. 2012
- [11] R. Sayle and A. Bissell, “RasMol: a program for fast realistic rendering of molecular structures with shadows,” *Proceedings of the 10th Eurographics UK '92 Conference, University of Edinburgh, Scotland*, vol. 92, pp.7-9, 1992

So Fair a Form: The Role of Gendered Bodies in Medieval Justice Systems

Audrey Saxton

Brigham Young University

Abstract

In the Medieval Romance tradition, there are many poems that link the physical male body with established power systems. Readers can observe this trend in Medieval romance texts such as Havelok the Dane and Sir Isumbras, in which the author collapses the hero's physical body with his political office. This rigid relationship between body and politics, however, only allows for narrow definitions of gender, power, and justice. If bodies try to deviate from these established definitions, violence is used to correct them and reestablish them firmly within the system. Also, in order for women to participate in this structure, they must alter their physical bodies to more closely align with the male body. However, there are other poems in the Romance genre, such as Marie de France's Sir Lanval and Chaucer's The Wife of Bath's Tale, that explore alternatives to this rigid structure through a depiction of female bodies. The hypersexualized and often bare female bodies provide an antithesis to male-dominated power structures; in place of violence, the female embodied system allows for choice, ambiguity, and

fluidity when faced with questions of power and justice. Through this short survey of Romantic poetry, readers can see the tensions between the social institutions of the male-dominated society and the imagined female alternatives.

In Medieval literature and philosophical writings, authors often use the human body as a metaphor for the political state. In this tradition, which the historian Ernst Kantorowicz most notably explored in his book *The King's Two Bodies*, the king has both a physical body, which is subject to pain, hunger, and death, and a political body, which is immortal and unchanging. While these two bodies are separate entities—and scholars have often noted “the perceived gap between the enduring nature of the king’s office and his human, mortal body” (McCracken 38)—in Medieval fiction, many authors consolidate these two bodies by creating a king or other political figure whose physical body reflects the inner qualities needed to govern the kingdom and practice justice. Readers can observe this trend in Medieval romance texts such as *Havelok the Dane* and *Sir Isumbras*, both of which collapse the hero’s physical body with his political office. But by combining the king’s two bodies, authors reproduce in literature a system that excludes women’s participation and demands that heroes use physical violence to establish justice. However, within this same genre, authors also propose solutions. Romance texts such as Marie de France’s *Sir Lanval* and Chaucer’s *The Wife of Bath’s Tale* present readers with female characters who both embrace their sexualized body and enact justice through nonviolent means. This nonviolent justice, based on female bodies rather than male, shows readers the varying medieval perspectives of justice and provides fantasized solutions to the real, historical problems of medieval male-dominated power systems.

Havelok and *Sir Isumbras* both contain male heroes whose physical bodies reflect their political power and position. Within these texts, authors consistently describe two physical features to identify male characters as noble or aristocratic: height and fairness, which often takes the form of light. When the pagan king first sees Sir Isumbras, he says, “Hys lemes are longe, hys bones grete,/ Hys eyen are graye and over stepe,/A knight hym semes to bee” [His limbs are long, his bones great,/ his eyes are gray and over bright,/ a knight him seems to be] (236-8). According to the historian Josiah C. Russell, “height was a factor which was noticed and commented upon by medieval men” (62). He goes on to note that the historical chronicles “when they do describe height . . . define a tall man as noble, as if they expected all nobles to be tall” (68-9). In history, as well as in literature, it was common for two

men to “size up” each other to judge physical abilities and noble birth. The pagan king in *Sir Isumbras* follows this trend; after making note of Sir Isumbras’s long limbs and bright eyes, the king specifically singles out Sir Isumbras as a knight: “A knight hym semes to bee.” In the mind of the king, and thus the poet, there is a connection between Sir Isumbras’s physical appearance and his knighthood. The poet furthers this connection when the king says, “He is a fayr man and hyghe,/ A fayrere sawe I never with yye,/ I gentyl man is hee” [He is a fair man and high,/ a fairer saw I never with eye,/ a gentleman is he] (241-3). Once again, the king points out physical features, that Sir Isumbras is “hyghe” and “fayr,” and links them with the social position “genteelness.” Through the pagan king’s observations, the poet collapses the gap between Sir Isumbras’s physical body and his political position. From this text, readers can see how, for medieval minds, height and nobility were intrinsically linked.

Readers find a similar pattern of combining the king’s two bodies in the romance *Havelok the Dane*. Havelok is a prince of Denmark sent into hiding by the Danish usurper Godard. When Havelok participates in the Lincoln games, the poet writes, “And the erles men woren al thore,/ Than was Havelok bi the shuldren more” [and the earls men were all there,/ then was Havelok by the shoulder more] (982-3). Not only is Havelok tall, but he is taller than all the earls, men of noble birth, by a whole head. However, unlike in *Sir Isumbras*, the characters in *Havelok* do not immediately recognize Havelok’s height as a mark of his nobility. Donna Crawford writes, “Havelok’s stature and strength signify for external view the interior characteristics of his nobility, at least for those able to read his body correctly.” Havelok’s body—like the poem’s words—becomes a text itself, with internal characteristics and noble birth written on its exterior for all to read. Yet Godrich, England’s treacherous king, misreads Havelok’s height; Godrich promised princess Goldeboru’s father “that I shude his douter yeve/ The hexte that mithe live,/ The beste, the fairest, the strangest ok” [that I should his daughter give/ to the highest that might live,/ the best, the fairest, the strongest also] (1080-2). The key word in Godrich’s promise is “hexte” meaning “high” or “lofty,” clearly in reference to someone’s birth. However, Godrich seeks to keep Goldeboru from an advantageous marriage by marrying her to someone “hexte” or “big, tall” (“hexte”). Havelok clearly fits the secondary definition of “hexte” and, unknown to Godrich, is also of noble birth. Because Godrich misreads Havelok’s height and simply writes him off as “sum cherles sone and no more” [some poor man’s son and no more] (1093), Havelok is able to regain his kingly status and “to help restore the disrupted social order” (Crawford). The Middle English word “hexte’s” ambiguity dem-

onstrates that nobility (the primary definition) and height (the secondary definition) were closely connected in Medieval thought (Middle English Dictionary). Furthermore, by using this word's slippery connotations to resolve the plot, the author demonstrates that Medieval authors were aware of the relationship between the male physical body and political position and manipulated it for narrative interest.

In addition to height, these romance authors include descriptions of light to indicate nobility. In *Sir Isumbras*, the pagan king notices his "stepe" eyes—a word here meaning "bright" or "shining" ("stepe", Middle English Dictionary). In *Havelok*, light appears in a more obvious manner. When Godard commands Grim to kill Havelok, his wife Dame Leve notices that "of hise mouth it stod a stem/ Als it were a sunnebem" [from his mouth it stood a stem/ as it were a sunbeam] (592-3). Light is one way that authors portray the "fairness" of their characters. According to the Middle English Dictionary, "fair" can mean "beautiful," "handsome," or "attractive," but it can also mean "light," "bright," or "shining" ("fair" 2a). The beam of light that shines from Havelok's mouth allows readers to quickly identify him as noble-born. This light also encourages Dame Leve to call her husband and then "unkeveleden him and swithe unbounden,/ And sone anon him funden,/ Als he tirveden of his serk,/ On his rith shuldre a kynmerk" [ungagging and swiftly unbinding him,/ soon anon they found,/ as they were taking off his shirt,/ on his right shoulder a birthmark] (602-5). The beam of light prompts Dame Leve and Grim to search Havelok's body for other physical manifestations, which they find in the form of a "kynmerk." The poet writes that the birthmark is "a swith brith, a swithe fair" [so bright, so fair] (606), which characterizes this physical mark as another manifestation of light. Upon seeing this mark, Grim says, "this ure eir,/ That shal louerd of Denemark!" [This is the true heir/ that shall be lord of Denmark!] (607-8). Because Havelok's physical body is associated with fairness and light, the other characters in the text can correctly identify his political position as king.

Versions of *Havelok* that predate the Middle English retelling, however, contain an episode where Havelock strengthens his kingly identity by sounding his father's horn rather than the anecdote about the "kynmark." Crawford writes that this omission "suggests the extent to which the inscription of the body is integral to the Middle English poem ... his essential kingly identity is marked on his body, in the 'kynemark' and the light from his mouth—not solely in his symbolic position or his abilities." In the Middle English version, the poet emphasizes the physical manifestations of Havelok's royal identity rather than the behaviors associated with nobility. This provides evidence that the theory behind combining the king's two bodies originated in me-

dieval thought and that Medieval authors were aware of this thinking. However, this also signifies that the problems associated with the political system centered on the male body were compounded during this time.

One of the most destructive problems that arise when the male body represents the political state is that the body becomes the site on which political leaders enforce justice. This means that to punish or correct any deviation from the system, kings and knights use physical violence. When Havelok fights against a band of thieves, the poet describes the scene in language that John Ganim says communicates an “exaggerated scale” of violence (30). The poet writes, “wit the barre so he him grette/ Bifor the heued that the rith eye/ Vt of the hole made he fleye” [with the bar he hit him so great/ on the head that the right eye/ out of the hole or socket made he fly] (1811-13). However, the thieves are not the only ones to suffer bodily violence; Havelok also leaves the battle with “wounde /Were a stede brout to grunde” [wounds that would bring a steed to the ground] (1979-80). Because this kingdom is accustomed to a king “that betere hel the lond to richt” [that better held the land to right] (109), the violence to both the thieves and Havelok’s bodies allows Havelok to establish justice and maintain “richt.” Through this violent punishment, Havelok establishes a pattern for his own rule; to preserve “richt,” violence must be used in every occasion. Now, violence is a normal and sought-after quality in leaders. Havelok further fortifies his violent reign during his battle with the usurper Godard. Once again, the poet uses descriptions of excessive violence: “that on the feld was neuere a polk/ that it ne stod of blod so ful,/ that the strem ran intil the hul” [that on the field was never a spot/ that it was not so full of blood/ that the stream ran into the hollow] (2685-7). Finally, Godard is sentenced to be flayed alive, a punishment that the author writes, “So it were grim or gore,/ That men mithe thethen a mile/ Here him rore” [It was so grim and gory/ That men might a mile from there/ Hear him roar] (2496-9). These descriptions of violence, although the poet admits they are overly sanguinary, still play an integral part in Havelok’s preservation of “richt.” Ganim says, “The poet delves into the grotesque when the subject approaches the socially problematic,” (29) suggesting that in order to deal with any departure from social norms, the poet creates Havelok as a character who relies on violence and bloodshed. While violence allows Havelok to regain his status as Denmark’s king, he also establishes a reign that esteems violent conflict over peaceful negotiations and capital punishment over rehabilitation.

Because the male body is strictly defined in terms of appearance (tall and fair), it becomes a rigid and limited structure, unable to bend

or change. The male justice system represents this inflexibility by rejecting other forms of justice in favor of violence. Therefore, while the male body is the site of power, it is ultimately restricting and confining, which leads to more failed heroes than successful ones; Roberta Krueger points out that in the *Vulgate Cycle* “only three knights emerge as capable of seeing the Grail” (143). She further notes that because of the rigid male role, “Violence between knights, jealousy between men over women, and verbal and physical abuse of women run as strong currents throughout romance” (144). Thus, the restrictive male body and justice system is not only detrimental to men but provides obstacles—and often abuse—for women especially when they participate in systems of male power.

Therefore, to create female characters who could successfully participate in the political structure, earlier authors wrote about women who either rejected their bodies or tried to adopt a male body. Within the English Epic tradition, women’s bodies are mostly absent; authors prefer instead to emphasize the adornment of the female body rather than the body itself. Hugh Magennis observes that “images of women in surviving Old English heroic poetry concentrate on mental qualities and on their external adornment, but do not normally specify physical beauty and do not highlight sexual attractiveness” (12). Hagiography also portrays women who are trying to replicate the masculine body. Alfric writes in Saint Eugenia’s *vita* that she “besought that they/ would shear her hair after the fashion of men,/ and disguise her with garments as if she were a boy” (Skeat 31). Eugenia observes the male body’s power and imitates it to participate in the Church’s male-dominated structure.

The romance genre, however, presents a shift in this trend. Rather than rejecting the female body, authors create female characters who embrace their sexualized form and still participate in systems of power and justice. For example, Marie de France strongly emphasizes the presence of a hypersexualized female body in her poem *Sir Lanval*: “Inside the tent was a maiden:/ her beauty surpassed the lily and the new rose/ ... / She lay on a very beautiful bed—/ ... / in nothing but her shift/ ... / Her side was entirely uncovered,/ her face, her neck, her breasts;/ she was whiter than hawthorn blossom” (lines 93-4, 96, 98, 100, 104-6). In this passage, Marie does not leave much to the reader’s imagination. The reader gets to see “her face, her neck, her breasts” rather than a veil, a necklace, or a dress as would have been common in the epics. Furthermore, Sir Lanval’s lover will go on to participate in questions of justice and punishment, not by imitating a male body, but with her own body. By bringing the female form into the foreground, Marie de France demonstrates how the romance genre shifts the em-

phasis onto the female body and sets the stage for the female form to participate in political matters.

Marie de France, by embracing the sexualized female body, also presents readers with an alternative to the traditionally violent methods of establishing justice. One of the central components of the justice system in the Middle Ages was trial by combat. If a disputation arose, each party was permitted to select a champion who would defend the accused and the accuser in single combat. Whoever won the battle was presumed to have God on their side, and justice was satisfied. In *Le Mort D'Arthur*, when Sir Mador de la Porte accuses Guinevere of poisoning the apple, he says, "And unto my oath *I will prove it with my body*, hand for hand, who that will say the contrary" (411, emphasis my own). Sir Lancelot defeats Sir Mador in single combat, reinforcing the system that emphasizes the male body's central role. In this system Guinevere is unable to prove herself innocent because she is a woman. However, in *Sir Lanval*, rather than calling upon a man's body to defend a woman's honor, the woman comes to "set him free" (588), reversing the typical relationship between male and female bodies. And, unlike Lancelot, Sir Lanval's lover is not expected to fight or kill to prove Sir Lanval's innocence; the simple presence of her body confirms the truth. In fact, she takes extra measures to make sure that everyone sees her body: "She dismounted before the king/ so that she was well seen by all./ And she let her cloak fall/ so they could see her better" (603-6). Sir Lanval's lover offers a nonviolent solution to the violent trial-by-combat method. While the way Marie de France's heroine achieves justice may not be ideal since it still relies on the female body's "to-be-looked-at-ness" (Mulvey 809), for the Middle Ages, Marie de France's *Sir Lanval* is revolutionary as it allows a woman to participate in the male centric power system while still embodying a female form.

The Wife of Bath's Tale also presents readers with a nonviolent alternative that still satisfies the demands of justice. In King Arthur's court, after the "lustly bachelor" (883) rapes a maiden, he is subject to death (898). However, King Arthur hands over his authority to Queen Guinevere, who can "chese whether she woulde him save or spille" (904). The queen decides to turn this choice back on the knight himself: he can either chose death or participate in a quest to discover women's greatest desire. By offering up this choice, the Queen provides the knight with a chance at rehabilitation. Susan Fein writes that "the Queen's sentence—death or wisdom—allows for reform" (339). The knight accepts the quest and must engage in intimate conversation and relationship-building with the women he meets instead of viewing them as objects of sexual pleasure, as he did before his crime. Justice is fur-

ther satisfied when during the course of his quest the knight promises to marry an ugly woman and share her bed to obtain the answer that will save his life. Fein explains, “the old woman’s faery justice is . . . similar to Arthur’s law in demanding, in altered form, ‘an eye for an eye’: a rape for a rape” (340). However, the knight’s sentence cannot be entirely equated with his violent sexual act against the young maiden at the beginning of the tale. The knight willing enters into the marriage contract and knows that the terms include sharing a bed with the ugly woman. Even when the female interpretation of justice seems confined to patriarchal traditions—by repaying a rape for a rape—the female body still reduces the violence and provides more choice when giving out sentences. Indeed, in the bedroom, the female body still offers choice: to have either a beautiful and unfaithful wife or an ugly and loyal one (1225-32). To modern readers, these choices may still appear limited; however, the fact that the female body offers choice at all indicates to a Medieval audience a radical shift away from the limited, rigid masculine justice and presents more flexible options.

While both male and female bodies take different forms in medieval romance texts, they are united through the prevalent description of their “fairness.” Havelok is a “fayr man” (962) and Chaucer’s female characters in the *Wife of Bath’s Tale* are also “fair” (1251). This word not only links male and female bodies but also hints at the important issues of “fairness” and “justice” in these romance texts. In these Medieval romances, the male body, through its rigid definition of both physical attributes and behaviors, can only offer readers with one option for justice—a violent option. However, the female body, because of its rejection of the male body and complete embrace of its sexualized form, opens up the discourse about what is appropriate in terms of reward, punishment, and justice. The romance genre’s portrayal of female bodies that break away from earlier literary forms is an appropriate medium for this type of experimentation because, as Jeff Rider notes, “The other worlds of romance are thus dream worlds in which the materially or morally frustrated aspirations of their authors and audiences may find at least veiled representations and imaginary satisfaction” (122). Through the thought-worlds that authors create in these Medieval romances, readers can see the tensions between the actual social institutions of the male-dominated society and the imagined female alternatives. Therefore, the physical portrayal of women, the reclamation of their sexualized bodies, and the creation of a non-violent justice system provides an imagined solution to the historical problem of male-dominated power systems in the Middle Ages.

Works Cited

Chaucer, Geoffrey. "The Wife of Bath's Tale." *The Norton Anthology of English Literature: The Middle Ages*, 9th ed., edited by J. Simpson and A. David, New York: Norton, 2012, pp. 282-310.

Crawford, Donna. "The Vulnerable Body of *Havelok the Dane*." *Medieval Forum*, edited by G.W. Tuma and D. Hazell, vol. 1, 2002, <http://www.sfsu.edu/~medieval/Volume%201/Crawford.html>. Accessed Nov. 28, 2014.

Drake, Graham, Eve Salisbury, Ronald B. Herzman, editors. "Havelok the Dane." *Four Romances of England: King Horn, Havelok the Dane, Bevis of Hampton, Athelston*. Kalamazoo, MI: Medieval Institute Publications, 1999, pp. 73-185.

"fair." Adj. Def. 1a and 2. *Middle English Dictionary*, 2014.

Fein, Susanna. "Other Thought-worlds." *A Companion to Chaucer*. Edited by P. Brown, Oxford: Blackwell Publishers, 2002, pp. 332-48.

Ganim, John. "Community and Consciousness in Early Middle English Romance." *Style and Consciousness in Middle English Narrative*. Princeton: Princeton UP, 1983, pp. 16-54.

"hexte." Adj. Def. 1a. *Middle English Dictionary*, 2014.

Hudson, Harriet, editor. "Sir Isumbras." *Four Middle English Romances: Sir Isumbras, Octavian, Sir Eglamour of Artois, Sir Tryamour*. Kalamazoo, MI: TEAMS (consortium for the Teaching of the Middle Ages) in association with the University of Rochester by Medieval Institute Publications, Western Michigan U., 1996.

Kantorowicz, Ernst H. *The King's Two Bodies*. 1957. Princeton: Princeton UP, 1997.

Krueger, Roberta L. "Questions of Gender in Old French Courtly Romance." *Cambridge Companion to Medieval Romance*. Edited by R.L. Krueger, Cambridge: Cambridge UP, 2000, pp. 132-149.

Magennis, Hugh, "Gender and Heroism in the Old English *Judith*," *Writing Gender and Genre in Medieval Literature*. Edited by E. Treharne, Suffolk: D. S. Brewer, 2002, pp. 5-18.

Malory, Thomas. *Le Mort D'Arthur: The Winchester Manuscript*. Edited by H. Cooper, Oxford: Oxford UP, 1998.

Marie de France. "Sir Lanval." *The Broadview Anthology of British Literature: The Medieval Period*. Edited by J. Black et al., Peterborough, ON: Broadview Press, 2006, pp. 166-181.

McCracken, Peggy. "The Body Politic and the Queen's Adulterous Body in French Romance." *Feminist Approaches to the Body in Medieval Literature*. Edited by L. Lomperis and S. Stanbury, Philadelphia: U of Pennsylvania Press, 1993, pp. 38-64.

Mulvey, Laura. "Visual Pleasure and Narrative Cinema." *Film Theory and Criticism: Introductory Readings*. Edited by L. Braudy and M. Cohen, New York: Oxford UP, 1999, pp. 833-44.

Rider, Jeff. "The Other Worlds of Romance." *Cambridge Companion to Medieval Romance*. Edited by R.L. Krueger, Cambridge: Cambridge UP, 2000, pp. 115-131.

Russell, Josiah C. "Tall Kings: The Height of Medieval English Kings." *Twelfth Century Studies*, Norwalk: AMS Press, 1978, pp. 62-75.

Skeat, Walter W. editor. "Saint Eugenia, Virgin." *Aelfric's Lives of Saints*. Oxford: Early English Text Society, 1881, pp. 25-51.

"stepe." Adj. Def. 3a. *Middle English Dictionary*, 2014.

The Epiphany of Tuskegee Airman Charles Sumner Stone, Jr.

Thomas Clark Terry
Utah State University

Abstract

Time and selective national memory have burnished the culture surrounding World War II's "Greatest Generation." While the manpower of African Americans was essential to the war effort, they were deeply conflicted and angry that the U.S. needed them overseas, but denied them equality at home. The most visible examples of African American commitment to the war were the Tuskegee Airmen, legends as fighter pilots in the skies over Europe. But many Tuskegee Airmen were draftees and had no burning passion to fight and die for a racist country. Charles S. Stone, Jr. was one of them, transplanted abruptly from Connecticut to a far different world in Alabama. This study examines Stone's Tuskegee experience through Norman Denzin's interpretive biography framework, identifying his wartime experience epiphany that was the pivot of his later career. After the war, Stone broke numerous color barriers as the first African American member of the White House press corps and of white Philadelphia newspapers. His career included two Pulitzer Prize nominations, the Congressional Gold Medal, editorship of three prominent black newspapers, and prestigious professorships at two major universities.

How did you get to Tuskegee [Alabama]? “Well, in the Army, of course. I was drafted. The Air Corps was segregated, so we were sent to Tuskegee for basic training.”

– Charles S. Stone, Jr.¹

America had a conundrum during World War II. The nation was racially segregated—a reality reflected in its armed forces no less than elsewhere—and yet it needed the manpower African Americans could provide to fight the war. The years have burnished the harsh realities of the time, and national nostalgia bordering on adoration for the “Greatest Generation” has replaced it. Among African Americans at the time, this was not so self-evident. “I’m trying to avoid this as much as possible,” Charles “Chuck” Stone recalled. “I didn’t feel any great patriotic fervor. Or as Samuel Johnson said, ‘Patriotism is the last refuge of scoundrels.’ And I didn’t want to be a scoundrel.”²



Charles S. Stone, Jr. as a Tuskegee Airman. *Photo circa 1945.*

¹ Charles Sumner Stone, Jr., interview by Thomas C. Terry, April 3, 2002, Chapel Hill, NC, transcript.

² *Ibid.*

I. A Segregated Military and the Tuskegee Airmen

African Americans generally were conflicted in the 1940s. The “Double V” campaign was the result: victory against segregation at home and victory for democracy overseas.³ For many African Americans, this was confusing and unsatisfying. Polls found only 25% felt they would be worse off personally and as a race if the Japanese won the war.⁴ Into this volatile mix was thrown a group of African American men, mainly college educated. Some were drafted and some volunteered. They all found themselves eventually at Tuskegee Institute, an all-African American college in Tuskegee, Alabama. While there, they were introduced to segregated military ways in the segregated South. Many of the Tuskegee Airmen, as they quickly came to be called, were from the North, including Stone. Dropped into the South where segregation was both institutionalized and pervasive, many African Americans had emotionally difficult times amid the indescribable violence of war and the ever-present violence of Jim Crow, reflecting the paradox that America as a nation and Americans as a people faced.

A quasi-military integration

In September 1940, President Roosevelt directed the War Department⁵ to give “colored men...equal opportunity with white men in all departments of the Army.”⁶ This did not equal integration of the military, a fact made clear by a War Department conference report a month later, which the president approved, acknowledging that “at this critical time” it was not deemed appropriate to “intermingle colored and white enlisted personnel in the same regimental organizations.”⁷ To integrate, the conference report continued, would be “destructive to morale and detrimental to the preparation for national defense.”⁸ By early 1941, the looming threat of American involvement in a world war finally compelled the War Department to begin building facilities to

³ The campaign was initiated by the leading African American newspaper of the time, the *Pittsburgh Courier*.

⁴ Donald Meckiffe and Matthew Murray, “Radio and the African American Soldier During World War II,” *Critical Studies in Mass Communication* 15:337-356 (December 1998), 343.

⁵ Predecessor to the Department of Defense formed after the Second World War.

⁶ While the president may have said Army, it became the policy to include African Americans in all branches of the armed services. The Marines did not receive its first African American enlisted man until mid-June 1942.

⁷ Charles E. Francis, *The Tuskegee Airmen: The Men Who Changed a Nation* (Boston: Branden Publishing Co., 1997), 48.

⁸ *Ibid.*

separately train African American aviators, with Tuskegee Institute selected as the principal training location.⁹

Not unexpectedly, the military devised a special test to effectively exclude African Americans, while maintaining the veneer of objectivity and fairness. The Army General Classification Test (AGCT) was intended to screen applicants for officers and identify special aptitudes of enlisted men.¹⁰ Military leaders expected few African Americans to qualify as officers or for flight training and were surprised when nearly 300 of 2,500 African American enlistees passed and fully qualified for officer training, a greater percentage than among whites.¹¹

II. The Method: Interpretive Biography

Norman Denzin is the principal architect of the qualitative, interpretive biography method. Interpretive biography differs from traditional-style biography by “creat[ing] literary, narrative accounts and representations of lived experiences,” rather than solely a “written account or history of the life of an individual.”¹² The interpretive approach, in Denzin’s estimation, conveys the essence of the individual through his or her personal experiences. Classic biography, Denzin contended, is a “simplistic model.”¹³ Ingeborg Helling noted there is not an ideal “correlation between the sequence of events judged as relevant by the researcher...called ‘objective career points,’ and the subject’s experience of them.”¹⁴

Denzin’s concept of a life hinges on what he termed epiphanies¹⁵ and what Jean-Paul Sartre considered turning points, when a “life is divided into two heterogeneous parts: before and after the sacred drama.”¹⁶ For Stone, Tuskegee and World War II were his epiphanies and the pivots of his entire life subsequently: there was the crucible of

⁹ Ibid., 147. Cadets used an airport 10 miles away until the Tuskegee field was finished, a process that took nearly a year.

¹⁰ Ibid., 150.

¹¹ Ibid., 152. A lawsuit in mid-January 1941 by Yancey Williams goaded the military into speeding up its timetable. He sued for reconsideration of his request for flight training and was eventually admitted to military flight school over two years later. One of the attorneys assigned by the NAACP to assist Williams was future Supreme Court Justice Thurgood Marshall.

¹² Norman K. Denzin, *Qualitative Research Methods Series*, 52, vol. 17, *Interpretive Biography* (Newbury Park, London, and New Delhi: Sage Publications, 1989), 41.

¹³ Ibid.

¹⁴ Ingeborg K. Helling. “The Life History Method: A Survey and a Discussion with Norman K. Denzin,” *Studies in Symbolic Interaction* 9:211-243, 1988, 239.

¹⁵ Ibid., 22.

¹⁶ Jean-Paul Sartre, *Saint Genet: Actor and Martyr* (New York: Pantheon, 1952/1963), 1.

his training as a Tuskegee Airman before his long career and then a denouement in the twilight of his career as he reassessed his Tuskegee experience in interviews and college classrooms. Denzin specifically defined an epiphany as a “moment of revelation,” something that seems apparent looking back on Stone’s World War II service.¹⁷ It does not even matter that the turning point was essentially accurate or that it was a reimagined construct of reality as myth. It only matters that the person who lived the experience believed the turning point was significant.¹⁸ Denzin identified four forms of epiphanies, some overlapping: major, minor, relived, and illuminative.¹⁹ That World War II and segregation (as individual incidents and as a whole) were significant epiphanies in the lives of the Tuskegee Airmen is indisputable. Karl Marx remarked that men (and women) “make their own history, but not...under conditions they have chosen for themselves; rather on terms immediately existing, given and handed down to them.”²⁰ A more perfect summation of the situation the Tuskegee Airmen found themselves in just after Pearl Harbor would be hard to articulate.

But looming over all other considerations and epiphanies is the influence of something Denzin failed to identify and perhaps even consider: the influence of race. Race could be inferred from his classification of the influence of gender and class. This present work centers race at the heart of the Tuskegee Airmen’s story and provides the context and the prism through which their entire experience must be viewed. Race shaped the lives of the Tuskegee Airmen in their youth, and its consequences molded their lives during military service and afterwards. In his book on Flaubert, Sartre identified a universal singular to explain a discursive figure like the Tuskegee Airmen.

What...can we know about man? For a man is never an individual; it would be more fitting to call him a *universal singular*. Summed up and for this reason universalized by his epoch, he in turn resumes it by reproducing himself in it as singularity. Universal by the singular universality of human

¹⁷ Denzin, *Interpretive Biography*, 47.

¹⁸ *Ibid.*

¹⁹ *Ibid.*

²⁰ Karl Marx, “From the Eighteenth Brumaire of Louis Bonaparte,” *The Portable Karl Marx*, E. Kamenka, ed. (New York: Penguin, 1852/1983), 287.

history, singular by the universalizing singularity of his project, he requires simultaneous examination from both ends.²¹

In this study, “universal plural” is substituted for the singular to denote the group nature of the Tuskegee Airmen’s experience, epitomizing the experience of all the individuals in a particular group, according to Denzin.²² “The broad outlines are the same,” he asserted.²³

III. Chuck Stone, Tuskegee Airman

Charles Sumner Stone, Jr. was born on July 21, 1924, in St. Louis, Missouri but moved when very young with his parents to Hartford, Connecticut. He graduated from high school with honors as “class prophet” in 1942 and was drafted in 1943, mustering out in 1945. Three years later, he graduated as the first African American graduate in decades from Wesleyan University in Middletown, Connecticut, after turning down admission to Harvard University.²⁴ He earned his M.A. in sociology from the University of Chicago in 1951 and spent one year at the University of Connecticut Law School before turning to other pursuits.²⁵ During several years in the 1950s, he worked for the humanitarian aid agency CARE in India and Egypt.²⁶ Then came stints at the African American newspapers *New York Age*, *Washington Afro-American*, and *Chicago Defender*, where he was editor-in-chief.²⁷ For several years in the 1960s, Stone worked as a special assistant to New York Congressman Adam Clayton Powell, Jr., coordinated work of the House Education and Labor Committee, and was employed by the American Committee on Africa.²⁸ Stone was also one of the first African American White House correspondents and a photo of him asking a question of President John F. Kennedy graced the wall of his University of North Carolina at Chapel Hill office for years.²⁹ There was another crinkled black and white photo also on the wall of him with FBI director J. Edgar Hoover, who granted him an exclusive interview in

²¹ Jean-Paul Sartre, *The Family Idiot: Gustave Flaubert*, volume 1 (Chicago: University of Chicago Press, 1971), ix-x.

²² Denzin, *Interpretive Biography*, 15.

²³ Norman K. Denzin, *The Recovering Alcoholic* (Newbury Park, London, and New Delhi: Sage Publications, 1987), 18.

²⁴ He was also chosen as commencement speaker.

²⁵ Stone interview.

²⁶ “Chuck Stone: Education Makers, Media Makers,” *The History Makers*, August 5, 2005, online.

²⁷ *Ibid.* He was fired for criticizing Mayor Richard J. Daley.

²⁸ *Ibid.*

²⁹ *Ibid.*

the wake of a scandal. “I was the only newspaper not to criticize him editorially,” Stone stated. “But it was only because I was in bed with the flu. I never told him that.”³⁰ Stone was the founding host of the PBS show “Black Perspectives on the News” and appeared for decades as a pundit on numerous national TV shows. He was a columnist and senior editor of the *Philadelphia Daily News* from 1972 through 1991. Because of his reputation, Stone served as a mediator between the Philadelphia police and accused murderers. In all, 73 men—all African Americans—surrendered to Stone.³¹ He helped free six hostages and defuse a riot at the Pennsylvania Correctional Institute at Graterford.³² Twice nominated for the Pulitzer Prize, Stone was a founder and first president of the National Association of Black Journalists. He taught journalism for several years at the University of Delaware and in 1991 was hired by the School of Media and Journalism at the University of North Carolina at Chapel Hill as Walter Spearman Distinguished Professor. He retired in 2005 and died in 2014.³³

Drafted

In April 1943, Stone was drafted after completing his first year at Wesleyan College and shipped initially to Camp Lee, Virginia. The great-grandson of a slave on his mother’s side—there were no slaves on his father’s side—he had never been in the South before. His neighborhood in Hartford was racially integrated, and he had felt none of the oppression and violence of segregation. Not so his mother. When she visited her son at Camp Lee, he picked her up at Petersburg, Virginia. “She got off the train, and it was warm and hot and sticky,” Stone recalled later. “She said, ‘You know, I grew up with this when I was a little girl, and I don’t mind segregation.’”³⁴ Unfamiliar with and angered by it, organized societal racism struck Stone hard. “It was a way of life,” he said. “It was institutionalized. The signs, plus the mores.... The laws enforced segregation. Schools were segregated (as were) the neighborhoods.”³⁵

For two years, Stone was shuttled around a succession of southern military bases for training in gunnery, navigation, bombing, even truck driving, never once being assigned overseas. At Kessler Field, Missis-

³⁰ Stone interview.

³¹ John F. Morrison, “Chuck Stone, a Major Force In and Out of the Newsroom, Dies at 89,” *Philadelphia Daily News*, April 7, 2014, online.

³² *Ibid.*

³³ Stone, *The History Makers*.

³⁴ *Ibid.*

³⁵ *Ibid.*

sippi, he took the Air Corps test, scoring best as a navigator, though he wanted to be a pilot. He acknowledged he had “lousy motor skills” and could not tell when he was upside down in a flight simulator.³⁶ A succession of assignments took him to Tyndall Field in Texas for gunnery training. Six weeks of training in geography, physics, and aerodynamics was also wedged in there. Then he went to Hondo, Texas, for navigator training. After qualifying as a navigator, he was sent to Tuskegee, Alabama, for bombardier training. “I was a damn good bombardier,” Stone said. “I really was. I loved it, the joy of hitting your target.... You plug in your air speed, then to see this thing happen. It’s really an exhilarating experience. I enjoyed bombardier training.”³⁷

Stone later recalled one technique to avoid sending African Americans into the war; they kept requiring more and more certificates and training.

“[W]hen you finished navigation, because it was segregated, you couldn’t go overseas—you couldn’t fly with the whites, and they were segregated, they sent us to bombardier training, and we stayed in bombardier training. And the war ended when I was in bombardier training. There were some guys, before us, who took navigation, bombardier training, and when they finished bombardier training they sent them to pilot training, and they had triple ratings. They were navigators, bombardiers, and pilots. They didn’t know what to do with [us].”³⁸

“[They] just kept moving us through the system, that’s all,” he added. “As far as I was concerned, it was a great deal. I didn’t have to go overseas. So that’s one time segregation paid off,” he concluded with a laugh.³⁹ Some of the black soldiers and fighter pilots, however, were zealous to prove themselves—and their race—in combat.

[The pilots] had these purple scarves, and they were really audacious. Whenever [a white bomber crew] was with them they knew they were going to get home safely because the white guys, when they’re flying escorting the bombers, would fly above the bombers. The 99th [African Americans] would fly below the bombers and take on the Germans and there were all kinds of [anecdotal] stories about them. One guy shot down

³⁶ Ibid.

³⁷ Ibid.

³⁸ Ibid.

³⁹ Ibid.

two German planes in one day, and the Germans had never seen black pilots before, and there were all kinds of stories. [S]o when this one guy shot down two planes, then they knew there was something different about them. Some kind of exotic quality in their midst [and their reputation] just multiplied.⁴⁰

But Stone was not so gung-ho. “I didn’t feel any great patriotic fervor. I didn’t feel the slightest shame in trying to avoid combat, I didn’t have no problem with that,” Stone said with a slight smile.⁴¹ He remembered watching a movie on the Bataan Death March during military training. “It scared the hell out of me...I’ll never forget. ‘God,’ I said, ‘This is a dangerous damn war.’ And that’s when I decided, I said, ‘I’m not going to pursue this. I’m going to get out of this somehow.’”⁴² The military, Stone continued, helped with this decision by not being overly interested in sending him and many other African Americans into combat.⁴³

No accommodations with segregation

Unlike his mother, he did not accommodate himself to segregation, although he largely escaped any brutal consequences for his actions. While stationed near San Angelo, Texas, a “hot as hell” day gave him a hankering for an ice cream soda.

And not thinking, I walked into this drug store, sat down at the counter. I had my uniform on, and I just wasn’t thinking. And so, I said, “I’d like a strawberry ice cream soda.” That was my favorite. And one of them said, “I’m sorry, we don’t serve (racial expletive).” And I said, “Oh, I don’t care, I still want an ice cream soda.” She looked at me, and she walked away, said something to somebody, came back and said, “You want vanilla ice cream or strawberry ice cream?” And she served me. But there are stories of guys getting arrested. I just wasn’t thinking about this issue. I wasn’t hostile or upset. Another time I went to the PX [base store] in Camp Lee, and ordered something. And sat at the counter. And the story spread about Chuck Stone, you know, challenging segregation. I wasn’t try-

⁴⁰ Ibid.

⁴¹ Ibid.

⁴² Ibid.

⁴³ Ibid.

ing to be courageous. I just grew up in the North, and I didn't accept this. And I refused to succumb.⁴⁴

There were other acts of resistance nationwide. In 1943, African Americans at Camp Kearns Army Air Forces Base⁴⁵ in Utah integrated the whites-only movie theater, the only source of entertainment available on the base, prompting other African Americans around the country to do the same. "We would go in and sit where [we] wanted," Stone noted. "It took those guys [at Kearns] to do it. So you had little things like that that people would challenge."⁴⁶ The white establishment, however, held the upper hand. Squinting his eyes, Stone continued, "But you knew that if you ever had a real major confrontation you wouldn't win it. You knew that. We weren't stupid."⁴⁷

Stone's navigation skills were a little uneven initially, he admitted, giving the Army an opening.⁴⁸ His training officer sent him on a pass-fail mission, what Stone called a "zero-zero" assignment.⁴⁹ A "big heavysset (white) guy, a mean son-of-a-bitch" tested Stone on a trip to Biloxi, Mississippi. "He just didn't like black cadets or black people."⁵⁰ Stone promised him, "We're going to go right down the middle of Main Street at 5:45."⁵¹ At the appointed time, "he turned around and...smirked at me," Stone said. "We were going right down the middle of Biloxi, right on time...and that's why I didn't wash out."⁵² Eventually, Stone trained other Tuskegee Airmen as navigators.

White soldiers sometimes refused to salute Stone, something he typically shrugged off. African American civilians, however, often did salute him. "I dated a woman for three or four months, and it was an overnight trip from San Angelo to Fort Worth," Stone remembered,

⁴⁴ Ibid.

⁴⁵ During the war, Kearns was the third largest city in the state, covering 5,000 acres with 1,000 buildings and 40,000 personnel. Eventually, 90,000 navigators, bombardiers, and pilots were trained at the base. It also maintained nine squadrons of B-24 and B-29 bombers. Little now remains, principally the airfield itself, part of South Valley Regional Airport. The 2002 Olympics speed skating oval is located in the Kearns area, a township in Salt Lake County. Japanese Americans, relocated after Pearl Harbor by rail, would usually stop at Kearns for food, water, and exercise en route to Topaz, one of the three "relocation" concentration camps in Utah.

⁴⁶ Ibid.

⁴⁷ Ibid.

⁴⁸ During World War II, what would become the separate U.S. Air Force was part of the Army.

⁴⁹ Stone interview.

⁵⁰ Ibid.

⁵¹ Ibid.

⁵² Ibid.

looking out the window of his Chapel Hill office. "Every time I got on the bus [in uniform], I went to the back because it was segregated."⁵³ The other African American passengers always relinquished their seats and or even allowed him to curl up to sleep, taking up several seats... while they stood all night. "They were very proud of me," Stone stated. "You've got the wings on. That was a big thing, wearing those wings. That really set you apart."⁵⁴

"When you walked down the street, people really acknowledged that," Stone continued. "The black people were so proud of you. There's glamour to it. And there were so few of us. And we were the epitome to be Air Corps."⁵⁵ Then, he would return to his base...and the humiliation of segregation in the South. "There were some German war prisoners down in Hondo," Stone pointed out, shaking his head, still angry at the memory. "And they could go anywhere they wanted because they were white, and we couldn't. [They] were treated better. And they were the enemy."⁵⁶ To fight for a country that would treat some of its citizens so poorly that Nazi troops were treated better? "We saw the inconsistencies," Stone admitted, "the inherent contradictions. We talked about it all the time."⁵⁷

Out of the military, out of the South

Once Stone left the military, he left the South behind, not returning to work there for nearly half a century and only after his wife finally convinced him the "new" South was different. Even Martin Luther King, Jr. could not change his mind initially. "He offered me a job as Executive Director of [the] Christian Leadership Conference in 1967, [and] I flew out to Chicago to meet with him," Stone recalled and asked King where he would work. "He said, 'Atlanta.' I said, 'No way, that's in the South.'"⁵⁸ King tried to convince him the South had changed, but Stone countered, "'Yeah, how come you're marching so much?'" To Stone, "the South was like a never-never land. I just wasn't going to live there, work there."⁵⁹

When he decided to accept the professor position at the University of North Carolina at Chapel Hill, many of his friends were wary. "[They] didn't think I was going to be able to survive," Stone recol-

⁵³ Ibid.

⁵⁴ Ibid.

⁵⁵ Ibid.

⁵⁶ Ibid.

⁵⁷ Ibid.

⁵⁸ Ibid.

⁵⁹ Ibid.

lected. “They joked about Jesse Helms and letting me stay here. John Praxta, assistant managing editor of the [Philadelphia] *Daily News* where I was a senior editor, he said, ‘Chuck, when you go, I’ll be your Northern correspondent.’ I said, ‘What’s that for?’ ‘To tell you where the troop movements are.’”⁶⁰

IV. Epiphany and Contradiction

The Tuskegee Airmen “were attempting to achieve two victories—to stop Hitler overseas and to stop racism in America,” according to historians Lawrence P. Scott and William M. Womack, Sr.⁶¹ “[T]he African-American pilots...overcame racial barriers just to fly airplanes” and “in the process, they provided the foundation for the modern day civil rights movement.”⁶² The Tuskegee Airmen “personif[ie]d the near-schizophrenic struggle for civil and human rights in a democracy during the struggle for survival in defense of democracy in a foreign land,” they concluded.⁶³ This contradiction played out in Stone’s career and in his family. His mother may have accepted the realities of mid-century southern bigotry and even felt comfortable in it, but not her son. He was infuriated by exposure to institutionalized racism during his military experiences in the South. And he was delighted not to fight or die for the system. The years may have mellowed him and the distance from Jim Crow and possible death in battle may have increased. Reflection, epiphany, and a lifetime of experiences and reflection may have sharpened his patriotism over the years, starting less than a decade after the war and providing a more nuanced and defensive perspective. Stone’s white roommate in graduate school “had seen a lot of combat...and used to always tease me,” Stone said. “‘Charles, you really were a faker, you didn’t serve your country.’ I said, ‘Well, I wasn’t allowed to serve my country.’”⁶⁴

As the years progressed, Stone began attending reunions of the Tuskegee Airmen and acknowledged with a laugh how some of his fellows exaggerated their role in the war, while at the same time accepting the accolades and recognition that came from being a Tuskegee Airman.

⁶⁰ Ibid.

⁶¹ Lawrence P. Scott and William M. Womack, Sr., *Double V: The Civil Rights Struggle of the Tuskegee Airmen* (East Lansing: Michigan State University Press, 1994), 1.

⁶² Ibid., 2.

⁶³ Ibid., 1.

⁶⁴ Stone interview.

The only thing we could wear was a discharge ribbon. I had two, [including] meritorious service. And some reunions later on, when they wore their uniforms, guys would have a whole chestful [of ribbons]. I remember this guy from Philadelphia. I said, “Sam, what the hell are you [doing]? And he said, “Hey, Chuck, nobody knows the difference.” It’s tempting, it really is. You’re respected when you served in the military. But were you in combat? Did you serve in combat?⁶⁵

In late March 2007, Stone was in the Rotunda of the U.S. Capitol to receive the nation’s highest civilian honor, the Congressional Gold Medal, and to be praised—and saluted—by President George W. Bush. The president apologized for the “unforgivable indignities” the Tuskegee Airmen endured.⁶⁶ “The Tuskegee Airmen helped win a war,” Bush said, “and you helped change our nation.”⁶⁷

V. Dénouement

The Tuskegee Airmen, NAACP Past President Benjamin L. Hooks observed, “knew that the future success of the civil rights movement was inextricably tied to their success in combat...[and] the success of the Airmen would help belie, at the core, the basis for racial discrimination in America—white supremacy.”⁶⁸ Chuck Stone’s career and life—that moment of epiphany—was a turning point in American history as well and a bridge from the segregation before World War II and the nation’s refusal to address it to the modern Civil Rights movement that accelerated into the 1950s and 1960s. After World War II, Stone was a pioneer African American newspaper and television journalist, worked for civil rights icons, mediated potentially violent stand-offs with police and accused criminals, and took his experiences into the classroom.⁶⁹

•

“After September 11, you realized [what] was important,” Stone emphasized a year after the 2001 terrorist attacks. He could have just as easily been talking about the Double V campaign of World War II.

⁶⁵ Ibid.

⁶⁶ William Douglas, “WWII Black Pilots, Tuskegee Airmen, Get Top Civilian Honor,” *Pittsburgh Post-Gazette*, May 16, 2017,” online.

⁶⁷ Ibid.

⁶⁸ Scott and Womack, *Double V: The Civil Rights Struggle*, xiii.

⁶⁹ His lecture classes of 70 or more students filled up in minutes.

“You close ranks, you really close ranks. Flying the American flag; we put in our window and our neighbors did, too. And my daughter said, ‘Daddy, you flew the American flag in the window?’ Damn right I did. As I should.”⁷⁰ Looking back, perhaps finding Denzin’s “moment of revelation,” Stone had modified, even softened, his observation on being a patriotic scoundrel through the epiphany of his time as a Tuskegee Airman. “I think because I was in World War II I had a stronger feeling about it,” Stone conceded, finding a distinction between two seminal events in American history. “Pearl Harbor was not as bad as [9/11] because they attacked a military installation, and it wasn’t our homeland. This was our homeland that got attacked.”⁷¹

An American flag lapel pin has become a touchstone of patriotism in recent years, but Stone chose not to wear one. Instead, he sported a Tuskegee Airmen pin, a visible reminder of his iconic status and sacrifice, uncomplicated by and unapologetic for his earlier delight at not actually having to serve in combat. The contradictions, justifications, and mixed emotions that characterize American history complicated Chuck Stone’s life as well.

⁷⁰ Stone interview.

⁷¹ *Ibid.*

Optimization of Broadband Multilayer Mirror Reflectivity via a Genetic Algorithm

Michael Greenburg, David D. Allred, R. Steven Turley
Brigham Young University

ABSTRACT

We report on the results of computationally designing and optimizing multilayer mirrors for broadband reflectivity in a region spanning from the vacuum ultraviolet to the infrared. Such a mirror would open up new possibilities for future space observatories. Because of the immense number of possible layer combinations and thicknesses for a multilayer mirror, we automated the mirror selection process with a genetic algorithm. Starting with a random object population within the simulation, a genetic algorithm iteratively selects and mutates the best portion of a population of objects that fit given design criteria to create a new population; this can be repeated as many times as desired. Our genetic algorithm yielded a high broadband reflectance mirror, which was then optimized via gradient search within the program. We found that placing a few layers under an aluminum coating can significantly increase extreme ultraviolet reflectivity, which would give access to important spectral lines such as that of the dominant He-II transition.

BACKGROUND

Space telescopes are limited as to the wavelengths they can collect. The Hubble Space Telescope, for example, can only practically collect photons with wavelength greater than about 1200 Å (visible light is around 4000–7000 Å, or 400–700 nm) and is the best ultraviolet telescope in space that retains the ability to collect visible and infrared light. An observatory that could collect photons with wavelengths ranging from many micrometers to less than 600 Å (far infrared to extreme ultraviolet), with designed reflectance peaks at even shorter wavelengths, would open up revolutionary possibilities for astronomers. For example, the ability to observe helium transitions at 584 Å and 304 Å would allow imaging of magnetospheres,¹ strong indicators of the habitability of planets.²

Within the next 20 years, NASA plans to put a telescope in space to succeed the James Webb Space Telescope (JWST), which is scheduled for launch in October 2018.³ The JWST will primarily observe infrared light, which offers advantages when viewing extremely distant objects. However, a space telescope that could observe from the infrared to the extreme ultraviolet would be the most versatile (and arguably most useful) observatory ever to be launched, and NASA is strongly considering pursuing such a telescope.³ Considering that the cost of the JWST (nearly \$10 billion) will likely be matched or superseded by its successor, investing in a more versatile mirror coating is in NASA's best interest.

BROADBAND MULTILAYER MIRRORS

In making the broadband mirror described above, the only realistic option for a primary coating is aluminum, which is unmatched in broadband specular reflectivity despite limitations such as rapid oxidation even at very low pressures. If these limitations are surmounted (another active area of our research), aluminum can reflect well to approximately 800 Å (Figure 1).⁴ More energetic photons tend to transmit through aluminum rather than reflecting and are converted to heat by the material very quickly. As such, using a thick aluminum layer as a mirror coating imposes a sharp limit on reflectivity. However, if the aluminum is sufficiently thin (e.g., 500 Å), absorption is low enough that one could place underneath the aluminum secondary layer(s) to reflect these more energetic photons back through it with minimal loss.⁵ Thus, a multilayer mirror can boost mirror performance for extreme ultraviolet photon energies while retaining near-identical infrared and visible reflectivity.

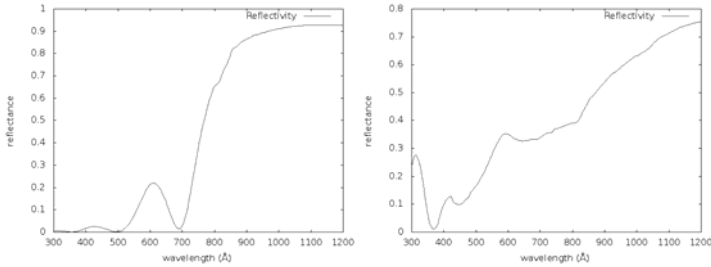


Figure 1: Theoretical reflectivity at 5° from normal. Although the mirror built by the program suffers reflectivity losses as compared with bare aluminum at wavelengths above 750 \AA , it retains enough reflectivity to be useful in that range and achieves 35% reflectivity at 584 \AA (the dominant He-I transition) and 25% reflectivity at 304 \AA (the dominant He-II transition). (a) A 500 \AA pure aluminum film atop a SiC substrate; (b) a mirror built by the program, composed of 10 layers (surface to substrate; thicknesses in \AA): Al (151), Be (39), Os (51), Ti (29), AlF_3 (6), Al (234), B_4C (54), Ti (41), Al (77), Au (94), SiC.

The amount and composition of layers must be chosen carefully. If the layer is too thick, a photon's energy will be absorbed before it can transmit, but there are practical limitations on how thin a layer can be deposited. Thickness would ideally be such that photons that are meant to transmit constructively interfere within the film. (Constructive interference occurs when the oscillations of two photons line up and combine their energy; destructive interference occurs when the opposite happens and the photons' energy is lost.) Because of the short wavelengths involved, layer thicknesses would need to be controlled rather precisely during fabrication to ensure constructive interference.

THE GENETIC ALGORITHM

A host of materials could potentially increase the specular reflectance of a mirror. Combined with the fact that a mirror of several layers of varying thicknesses is likely to be ideal, this means that there are billions of possible mirror permutations—rendering it impossible to find the ideal mirror by hand. Finding the ideal mirror is also rendered computationally difficult by the fact that there are surely many good mirrors with very different material composition—in other words, there are many extrema in mirror space. This is analogous to a sinusoidal

function, which has many local maxima and minima, and renders a computer unable to find a solution by simply picking a point and following the function up- or downhill; the computer will find a solution, but it is probably not the desired solution since it will represent a local extreme rather than a global extreme.

One of the best computational methods for locating a global extreme in such a function space is the genetic algorithm, so named because it mimics the evolutionary process governed by genetics. A genetic algorithm is implemented thus: A random population of objects is generated by the computer, then tested for fitness by an algorithm, known as a merit function, designed to determine its quality. Objects that are determined to be more fit have a better chance of parenting the next generation. The best few solutions are kept, and all the solutions are tweaked and melded in a process analogous to selective breeding, with the chance of trait propagation for an object being determined by its merit function. The process is repeated with this new population and can be iterated as many times as desired, eventually resulting in a highly optimized object population.⁶

Because of the random nature of the initial population, a genetic algorithm has a good chance of finding all or most of the extrema in a given function space. For this reason, it is likely to converge to the global extreme or something close thereto with the best object in the final population. Including the possibility of random mutations and cross-over in the process of creating offspring from parent populations allows for jumping from one local minimum to another, further enhancing the chance of convergence to the global extreme. The best object(s) can be refined via a gradient search, which essentially pushes the solution to its ideal extreme by testing what changes increase merit the most until it can no longer be increased.

METHODS

Programs were written in C++ and the Julia language. Reflectivity calculations were based on empirical data on material reflectivity from the repository at volta.byu.edu/nk/; since the data are discrete, interpolation was used to create a continuous reflectivity function for each material that was used by the program.

The mutation process of the genetic algorithm in the C++ version (the Julia version is similar) is as follows: The first iteration begins with an array of random mirrors, and subsequent iterations start with the array resulting from the last iteration. The mirror array is sorted according to merit at the beginning of each iteration, putting the best

mirrors at the beginning of the array. Part of the array for the next generation is filled with the best several mirrors from the current generation, and the rest is filled by crossing and mutating the current generation. Two parents for each child in the next generation are chosen according to array indices given by $\lfloor s(1-r^{1/3}) \rfloor$, where s is the size of the parent array, r is a random real number between 0 and 1 (with uniform distribution), and $\lfloor x \rfloor$ is the floor function (which rounds to the closest integer less than or equal to x); the floor function is used since C++ is a zero-index language, meaning that arrays have indices 0, 1, 2, etc. The cube root weighting ensures that more parents are selected from near the beginning of the array where merit is higher, leading to a better generation after each iteration despite some bad offspring. Once two parents are chosen, a cutoff layer is chosen randomly (again with uniform distribution), and the mirror inherits all layers below the cutoff layer from the first parent, and all layers above the cutoff layer from the second parent. If the next generated random real number between 0 and 1 is less than the mutation rate (normally set to 0.05–0.2), a randomly selected layer's material is changed or its thickness is changed (to somewhere between half and double the original thickness), with equal probability.

The crux of a genetic algorithm is its merit function, which determines the progenitors of the next generation—if it is faulty, the final population will be as well. Ours is based on a set of criteria dealing with mirror reflectivity, as calculated by the Parratt recursion formula based on Fresnel reflection coefficients⁷ and their relative weights (e.g., 50% weight on average reflectance over the 650–1200 Å range, 50% weight on reflectance at 304 Å). These, in addition to criteria such as angle of incidence of the incoming beam, could be easily modified based on the nature of the desired mirror. Parameters governing the mirror, such as the number of layers, and governing the simulation, such as initial population size, could also be modified. We found that drastically different results were attained with different mirror criteria (Figure 2). The program ran the genetic algorithm, put the best object in the final population through a gradient search to optimize it, printed the mirror's composition, and output a graph representing the reflectivity over a selected range (this usually took less than 15 minutes on an ordinary desktop computer).

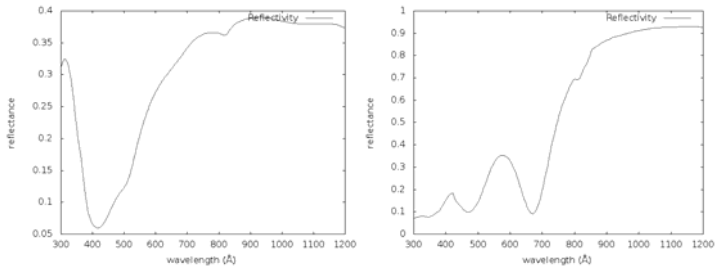


Figure 2: Calculated reflectivity at 5° from normal of mirrors built by the program based on different merit functions. Note the differing scales. (a) Merit function based solely on reflectivity at 304 \AA ; (b) Merit function based solely on average reflectivity between 800 and 1200 \AA

RESULTS

As calculated by the program, significant performance enhancements can be made by using a multilayer mirror. Mirrors built within the program routinely experienced significant boosts in range of collectible wavelength (Figure 1).

We found that for many merit functions, a host of mirrors of varying composition and very similar reflectivity resulted when the simulation was run several times (Figure 3, Table 1). Changing the criteria constituting the merit function, however, strongly affected the reflectivity profiles of the mirrors produced by the program (Figure 2).

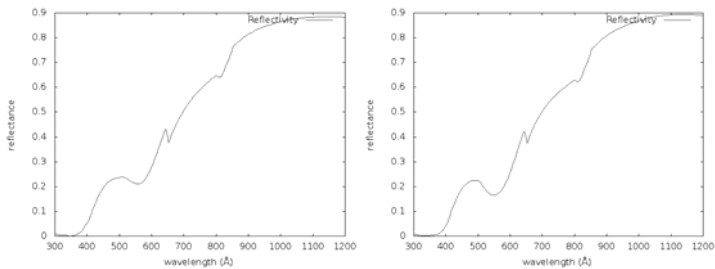


Figure 3: Reflectance vs. wavelength of two mirrors produced by the program using the same merit function; note the differences in composition. (a) Mirror composed of (surface to substrate): Al (281 \AA), Mo (113 \AA), W (26 \AA), Al₂O₃ (26 \AA), GaP (206 \AA), Hf (337 \AA), SiC (substrate); (b) Mirror composed of (surface to substrate): Al (279 \AA), Mo (138 \AA), Al₂O₃ (139 \AA), Tm (392 \AA), TiC (377 \AA), Tm (333 \AA), SiC (substrate).

Table 1: Material composition of 10 mirrors built by the program based on the same merit function

L1	L2	L3	L4	Merit
Co (3230)	Cu (2130)	Mo (2310)	SiC (360)	.76
K (710)	Mo (590)	Ge (1010)	Mo (610)	.73
Mo (5040)	CaF ₂ (300)	Li (5510)	Ir (760)	.73
Yb (1100)	GaAs (760)	Mo(560)	Os (440)	.73
Te (1330)	Sc (1700)	Mo (730)	B ₄ C (430)	.74
Mo (760)	Sr (2360)	ZnTe (560)	Ru (720)	.74
Lu (2310)	SrF ₂ (970)	Mo (720)	Te (420)	.74
Sc (800)	Si (1060)	Ir (660)	B ₄ C (350)	.73
Ta (770)	Ge (2620)	Ir (680)	B (330)	.74
Mo (4370)	Yb (2550)	Mo (680)	B ₄ C (430)	.73

Measurements of thickness in Å

Merit function (half weight on reflectance at 304 Å, half weight on average reflectance over the range 300–1200 Å). The substrate is bulk silicon carbide, layer 1 (L1) is atop the substrate, L2 is atop L1, etc. A layer of aluminum fixed at 500 Å is on top of L4.

DISCUSSION

The program was slowly refined; running it repeatedly revealed what led to better solutions and what didn't work. For example, it was found that interpolating materials' refractive indices with cubic splines meant that the program sometimes found a material's absorption to be below zero (i.e., amplification) when there were large data gaps; this was alleviated by using linear interpolation.

The fact that running the genetic algorithm multiple times with the same merit function often resulted in compositionally different mirrors with similar reflectivity is beneficial. Some mirrors built by the program would be chemically unstable or toxic if actually produced, and many would be extremely difficult to fabricate. Since there exist many solutions that offer similar performance (Table 1), one can likely find in the results of several simulations a good mirror that would also be stable and easy to fabricate.

Having fewer layers in a mirror implies easier fabrication; however, multiple layers do strongly enhance performance. More layers led

to significantly better reflectivity until 4–5 layers; after that merit continued to increase, but not as substantially (Table 2).

It should be noted that the list of materials to be used in the simulations was by no means exhaustive; materials were selected based on potential to enhance reflectivity and data availability.

Number of Layers	Merit
2	1.09
3	1.19
4	1.28
5	1.35
6	1.38
7	1.42
8	1.47

The merit function was based 1/3 on reflectivity at 304 Å, 1/3 on average reflectivity between 650 and 1200 Å, and 1/3 on peak width (amount of the reflectance peak above 50%) between 400 and 700 Å. Each merit calculation is the best of three runs.

CONCLUSION

Programs consisting of a genetic algorithm and gradient search for determining the ideal composition of broadband multilayer mirrors were programmed in C++ and the Julia language. The performance of multilayer mirrors was significantly better than that of simple aluminum mirrors, and relatively few layers were needed for significantly better reflectivity in the extreme ultraviolet. A broad set of mirrors often gave very similar reflectivity, implying that there is likely a mirror that is feasible to fabricate with similar characteristics to any given mirror. We thus conclude that a multilayer mirror with much greater capabilities than would be possible with a single-layer mirror could realistically be fabricated.

REFERENCES

- [1] I. Yoshikawa et al, "Development of a compact EUV photometer for imaging the planetary magnetosphere," *Journal of Geophysical Research*. 106(A11), 26057-64 (2001).
- [2] H. Lammer et al, "What makes a planet habitable?" *The Astronomy and Astrophysics Review* 17, 181–249 (2009).
- [3] P. Hertz, "Planning for the 2020 Decadal Survey: an Astrophysics Division White Paper," NASA Large Mission Concept Study (2015). Retrieved May 12, 2017 from https://smd-prod.s3.amazonaws.com/science-red/s3fs-public/atoms/files/White_Paper-Planning_for_the_2020_Decadal_Survey-signed.pdf.
- [4] J. I. Larruquert et al, "Far-ultraviolet reflectance measurements and optical constants of unoxidized aluminum films," *Applied Optics* 34(22), 4892-99 (1995).
- [5] J. I. Larruquert, R. A. M. Keski-Kuha, "Multilayer coatings with high reflectance in the extreme-ultraviolet spectral range of 50 to 121.6 nm," *Applied Optics* 38(7), 1231-36 (1999).
- [6] D. Whitley, "A genetic algorithm tutorial," *Statistics and Computing* 2(4), 65-85 (1994).
- [7] L.G. Parratt, C.F. Hempstead, "Anomalous dispersion and scattering of x-rays," *Physical Review* 94, 1593-1600 (1954).

Diastereoselectivity of the Nucleophilic Addition Reaction of the (\pm)-Menthylmagnesium Chloride Grignard Reagent with Phenyl Isocyanate

Rebecca L. Maedgen, Myla R. Pereira, and Nathan S. Werner

Southern Utah University

Abstract

Menthol is a chiral, natural product isolated from mint leaves and is an active ingredient found in some cough drops. It is a six-membered carbon ring that contains three substituents at stereogenic centers: an alcohol, an isopropyl, and a methyl group. The alcohol functional group can be transformed into a nucleophilic carbon-magnesium bond consisting of a 1:1 mixture of epimers. The stereoselectivity of the reaction of this diastereomeric mixture with phenyl isocyanate was studied. The reaction of excess (\pm)-menthylmagnesium chloride with phenyl isocyanate at 0°C produced the addition product in 53% isolated yield. No isomeric products were observed by analysis of the crude reaction mixture with gas chromatography coupled mass

spectrometry. ^1H NMR coupling constant analysis of the product suggests nucleophilic attack of an equatorial carbon-magnesium bond on the electrophile to produce the (\pm) - $(1R,2S,5R)$ -diastereomer of the product. The potential applications of this research are in the preparation of chiral menthol-derived catalysts for the production of stereochemically pure fine chemicals and medicines.

Introduction

Menthol **1** is a 6-membered carbocycle natural product with the molecular formula $\text{C}_{10}\text{H}_{20}\text{O}$ (Figure 1). It can be isolated from mint leaves and is commonly found in cough drops and cigarettes. It is a biologically active molecule that acts as a local anesthetic and provides a cooling sensation on contact.^{1,2} The ring has 3 substituents, an alcohol, an isopropyl, and a methyl group. Menthol is chiral and has 8 possible stereoisomers because all 3 substituents on the ring are bonded to stereogenic carbon atoms; nature primarily produces the $1R, 2S, 5R$ diastereomer **1**.

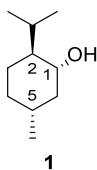
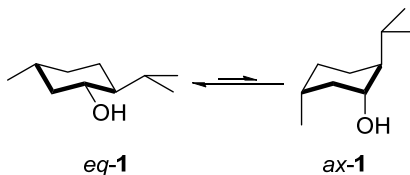


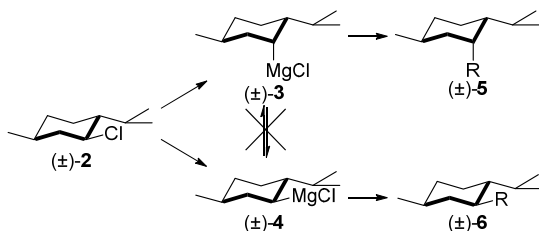
Figure 1. The structure of natural menthol.

The low cost and intrinsic structural properties of menthol have made it an appealing tool in asymmetric synthetic chemistry.³ Six-membered rings exist primarily as an equilibrium mixture of two low-energy chair conformations that minimize angle and torsional strain (Scheme 1). The lowest energy of these conformations places the sterically bulky isopropyl, methyl, and alcohol groups of menthol in equatorial positions (eq-**1**). This provides a rigid and predictable asymmetric environment about the menthol structure.



Scheme 1

Synthetic chemists are interested in reactions that attach the chiral menthyl unit to other molecules to utilize its unique structure.⁴ One convenient way to bond the C1 atom of the menthyl ring to other molecules is by transformation of the alcohol functional group into a Grignard reagent. The high nucleophilicity of the carbon-magnesium bond of the Grignard reagent increases the number of potential electrophiles and novel, chiral products. However, the radical production of the menthol-derived Grignard reagent by treatment of menthyl chloride (\pm)-**2** with magnesium shavings produces a 1:1 mixture of epimers at C1 (Scheme 2).⁵ Experiments suggest that these epimers are not in equilibrium and thus do not interconvert.^{5,6} Here we report our study of the diastereoselectivity of the nucleophilic addition reaction of (\pm)-menthylmagnesium chloride with phenyl isocyanate.



Scheme 2

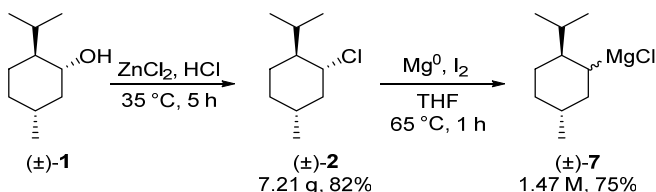
Results

Preparation of the (\pm)-Menthylmagnesium Chloride Grignard Reagent

The study of the stereoselectivity of the addition reaction of the diastereomeric mixture of the Grignard reagents ((\pm)-**3** and (\pm)-**4**) with phenyl isocyanate required the preparation of the reagent. The synthesis began with exposure of (\pm)-**1** (7.80 g, 49.9 mmol, 1.0 equiv) to Lucas' reagent (10.8 M solution of ZnCl_2 in conc. HCl, 15.3 mL, 166 mmol, 3.33 equiv) at 35°C for 5 h (Scheme 3). Purification by distillation provided 7.21 g (82% yield) of menthyl chloride (\pm)-**2** as a clear, colorless oil (bp: 96°C at 20 torr).⁷

The Grignard reagent (\pm)-**7** was then prepared by addition of (\pm)-**2** (5.01 mL, 29.3 mmol, 1.0 equiv) to an argon-purged suspension of magnesium shavings (0.856 g, 35.2 mmol, 1.2 equiv) in tetrahydrofuran (THF) (5 mL) under a balloon of argon. A crystal of iodine was dissolved in THF and added by syringe to initiate the reaction. The

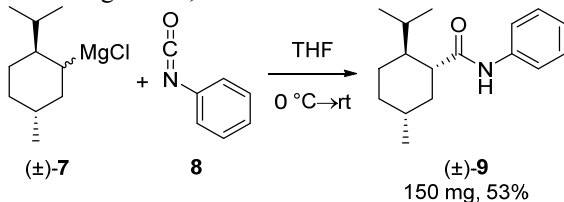
reaction mixture was heated at reflux for 1 h. The resulting grey, transparent suspension was diluted to 15 mL total volume with THF, and the solution was transferred by syringe to an oven-dried Schlenk tube that had been purged with argon for storage. The concentration of (\pm)-**7** was determined to be 1.47 M (75% yield) by titration.^{5,8}



Scheme 3

Nucleophilic Addition Reaction of Menthylmagnesium Chloride Grignard Reagent with Phenyl isocyanate

The stereoselectivity of the addition reaction of Grignard reagent (\pm)-**7** to phenyl isocyanate **8** could then be studied (Scheme 4). The reaction was carried out by addition of THF (2.2 mL) and **8** (120 μ L, 1.1 mmol, 1.0 equiv) to an oven-dried, 25-mL round-bottomed flask, containing a magnetic stir-bar, equipped with a septum, and purged with argon. The flask was cooled in an ice bath to 0°C and (\pm)-**7** (1.47 M, 1.47 mL, 2.2 mmol, 2.0 equiv) was added dropwise by syringe. The mixture was allowed to warm to room temperature by removal of the cooling bath. After 1 h at room temperature, an aliquot was taken and analyzed by gas chromatography–mass spectrometry. The reaction was then quenched with 6 M HCl, diluted with diethyl ether, washed with water and brine, and dried with sodium sulfate, and the solvent was removed *in vacuo*. The crude residue was purified by flash chromatography in a 1×20-cm column with 16 g of normal-phase silica gel and a gradient eluent beginning with 100% hexane and ending with 15% ethyl acetate/hexane. Concentration *in vacuo* provided 150 mg (53%) of (\pm)-**9** as a homogeneous, white solid.



Scheme 4

Data for (±)-(1R,2S,5R)-5-methyl-(1-methylethyl)-N-phenylcyclohexanecarboxamide (±)-9

mp: 114–116°C

¹H NMR: (400 MHz, CDCl₃, 7.26 ppm)
7.54–7.52 (m, 2 H), 7.34–7.29 (m, 2 H), 7.12–7.08 (m, 1 H), 2.14 (td, $J = 11.2, 3.6$, 1 H), 1.93–1.88 (m, 1 H), 1.82 (pd, $J = 6.9, 2.6$, 1 H), 1.78–1.70 (m, 2 H), 1.63 (tt, $J = 11.3, 2.9$, 1 H), 1.33 (p, $J = 12$, 2 H), 1.11–0.99 (m, 2 H), 0.93 (d, $J = 1.7$, 3 H), 0.91 (d, $J = 1.0$, 3 H), 0.82 (d, $J = 6.9$, 3 H).

¹³C NMR: (101 MHz, CDCl₃, 77.16 ppm)
174.1, 138.0, 129.0, 124.2, 119.7, 119.6, 50.9, 44.6, 39.4, 34.5, 32.3, 28.8, 23.9, 22.3, 21.4, 16.3.

IR: (neat)
3271 (w), 2961 (w), 2944 (w), 9904 (w), 2868 (w), 1651 (s), 1597 (s), 1537 (s), 1502 (m), 1442 (s), 1383 (w), 1345 (m), 1311 (m), 1299 (m), 1243 (m), 1186 (m), 1136 (w), 1031 (w), 1008 (w), 924 (w), 904 (w), 773 (w), 752 (s), 739 (s), 708 (m).

MS: (EI, 70 eV)
259 (M⁺, 11), 148 (9), 135 (10), 123 (10), 97 (9), 95 (6.04), 94 (11), 93 (100), 92 (6), 83 (44), 81 (7), 77 (10), 69 (14), 67 (6), 65 (5), 57 (9), 55 (22).

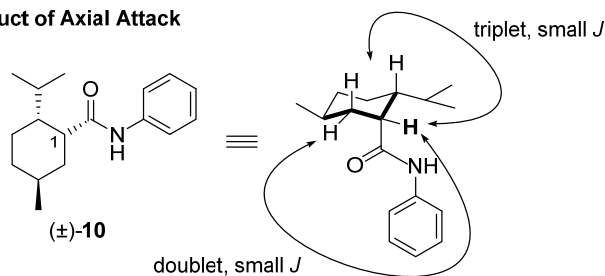
TLC: R_f 0.45 (15% ethyl acetate/hexane) [silica gel, UV light]

Discussion

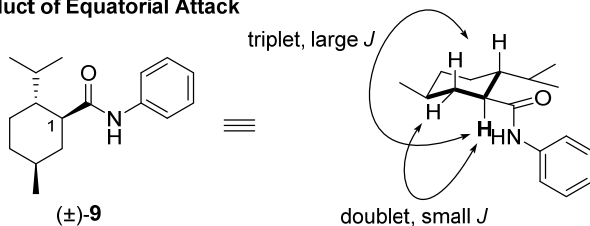
The determination of the stereochemical outcome of the reaction required correlation of the Karplus relationship to the ¹H NMR spectra of the addition product.⁹ The Karplus relationship correlates the dihedral angle of vicinal hydrogen atoms to the observed coupling constant. The relationship predicts that dihedral angles of 0° and 180° produce large coupling constants ($J = \sim 12$ Hz), and dihedral angles close to 90° produce small coupling constants ($J = \sim 2$ Hz). Therefore, two scenarios present themselves: axial attack of Grignard reagent (±)-5 to produce (±)-10, or equatorial attack of Grignard reagent (±)-4 to produce (±)-9

(Scheme 5). The ^1H NMR signal for the C1 hydrogen atom (Scheme 5, bold) of the product of axial attack (\pm)-**10** would be predicted to be an apparent triplet (or a doublet of doublets) with a small coupling constant resulting from the 2 axial hydrogen atoms at a $\sim 60^\circ$ dihedral angle, and a doublet with a small coupling constant resulting from the 1 equatorial hydrogen atom at a $\sim 60^\circ$ dihedral angle. The ^1H NMR signal for the C1 hydrogen atom (Scheme 5, bold) of the product of equatorial attack (\pm)-**9** would be predicted to be an apparent triplet (or a doublet of doublets) with a large coupling constant resulting from the 2 axial hydrogen atoms at an $\sim 180^\circ$ dihedral angle, and a doublet with a small coupling constant resulting from the 1 equatorial hydrogen atom at an $\sim 60^\circ$ dihedral angle.

Product of Axial Attack



Product of Equatorial Attack



Scheme 5

Fortunately, for this analysis, the signal of the C1 hydrogen atom of interest was the most deshielded alkyl hydrogen on the menthyl ring. The signal was found at 2.14 ppm and was well resolved from the other alkyl hydrogen signals in the spectra. This signal was clearly split into a triplet of doublets ($J = 11.2$ and 3.6 Hz, respectively) (Figure 2). Therefore, the signal consisted of a triplet with a large coupling constant and a doublet with a small coupling constant. This pattern is consistent with an equatorial attack of the Grignard reagent (\pm)-**4** on **8** and a stereochemical assignment of (\pm)-**1R,2S,5R** to the product. This result is also

consistent with the preferential reactivity of (\pm)-**4** observed with other electrophiles.^{5,6}

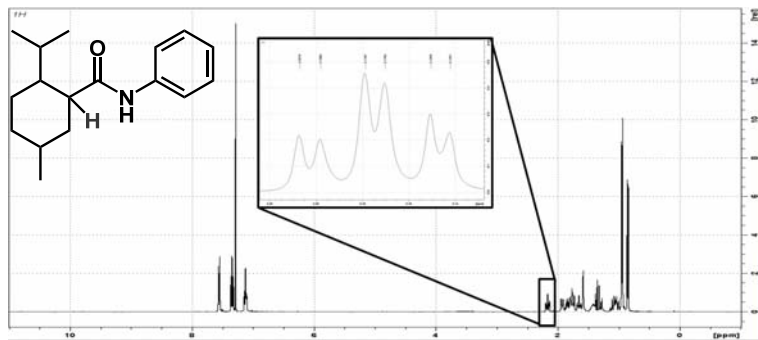


Figure 2. ^1H NMR spectrum of (\pm)-(1*R*,2*S*,5*R*)-5-methyl-(1-methylethyl)-*N*-phenylcyclohexanecarboxamide.

Conclusion

(\pm)-Menthylmagnesium chloride can be prepared from (\pm)-menthol in 62% overall yield. The reaction of (\pm)-**7** and **8** provides a single diastereomer of the addition product (\pm)-**9** in 53% isolated yield. ^1H NMR coupling constant analysis of the purified product supports a stereochemical assignment of 1*R*,2*S*,5*R* to (\pm)-**9**. The structure of the product suggests the preferential attack of an equatorial carbon–magnesium bond of (\pm)-**7** on the electrophile. The perfect selectivity observed suggests that it may be possible to use **8** as a sacrificial electrophile for the resolution of the diastereomers of (\pm)-**7**. Future work is directed toward the stereoselective production of other menthyl-derived products and their applications to asymmetric synthesis.

Acknowledgments

We are grateful to Southern Utah University for a Faculty Scholarly Support Fund Grant (N.S.W.), a Walter Maxwell Gibson Research Fellowship (R.L.M.), and an L. S. and Aline W. Skaggs Research Grant (R.L.M. & M.R.P.) to generously support this work.

References

- Galeotti, N.; Di Cesare Mannelli, L.; Mazzanti, G.; Bartonlini, A.; Ghelardini, C. *Neurosci. Lett.* **2002**, 322, 145–148.

2. Eccles, R. *J. Pharm. Pharmacol.* **1994**, *46*, 618–630.
3. Oertling, H.; Reckziegel, A.; Surburg, H.; Bertram, H.-J. *Chem. Rev.* **2007**, *107*, 2136–2164.
4. Whitesell, J. K. *Chem. Rev.* **1992**, *92*, 953–964.
5. Beckmann, J.; Dakternieks, D.; Druger, M.; Duthie, A. *Angew. Chem. Int. Ed.* **2006**, *45*, 6509–6512.
6. Zuzek, A. A.; Reynolds, S. C.; Glueck, D. S.; Golen, J. A.; Rheingold, A. L. *Organometallics* **2011**, *30*, 1812–1817.
7. Smith, J. G.; Wright, G. F. *J. Org. Chem.* **1952**, *17*, 1116–1121.
8. Gilman, H.; Zoellner, E. A.; Dickey, J. B. *J. Am. Chem. Soc.* **1929**, *51*, 1576–1583
9. Karplus, M. *J. Am. Chem. Soc.* **1963**, *85*, 2870–2871.

Effects of Roughness on Reflection of Monochromatic Light

Spencer Thevenin and R. Steven Turley
Brigham Young University

Abstract

If the scale of surface roughness is on the order of the wavelength of incident light, traditional optics methods like ray tracing and physical optics fail to adequately model reflectance. In this project, boundary integral techniques are used to compute the effects of roughness on two-dimensional conducting surfaces. Reflectance calculations for transverse-magnetic waves on a perfect conductor in two dimensions are analyzed in depth to model the effects of scattering from surface roughness. Root mean squared surface roughness more than a hundredth the wavelength of the incident beam is noticeable and anything larger than a tenth the wavelength dominates the reflectance. These calculations allow for comparison with previous approaches—such as the scalar correction factors of Debye-Waller—at various spatial frequencies. The Debye-Waller factor models the effects of smaller roughness well but loses precision as roughness increases. The effects of spatial frequencies are also analyzed and compared with the current work of Stearns in showing additional surface parameters affecting roughness. The results of altering spatial frequency support

the work of Stearns suggesting additional parameters like spatial frequency are factors that affect overall reflectance.

1 Introduction

In recent years, technology and innovation have extended the limits in the field of optics through the use of the extreme ultraviolet (XUV). The XUV is a region within the electromagnetic spectrum between 10 and 120 nm. With shorter wavelengths and greater energy, XUV enhances capacity and scope of many optical instruments. XUV has improved the precision of a recently developed desktop microscope created from a compact laser-plasma.¹ This microscope has provided better resolution and detail than similar microscopes using lower energies. Improved performance was also found in XUV contact-hole printing.² Because of smaller wavelengths there was improved control and faster etching.

Lately, NASA has been interested in improving their telescopes to detect and utilize XUV light. This ability would improve the imaging and detection of stars as well as provide enhanced analysis of their composition. The telescopes contain mirrors that are vital to control, reflect, and magnify incoming and outgoing light. The Turley-Allred XUV research group at BYU has been working on developing mirrors that meet this criteria.³ The group has made progress towards this goal but have run into a few challenges along the way. One problem arises from the inability to create a perfectly smooth surface.^{4,5}

The smaller wavelengths of XUV present problems in calculating reflectance. The wavelengths of XUV light approach the size of the roughness on the surface of the mirror. The resulting scattering of light is less obvious and more unpredictable. This is better understood through an analogy.

The effects of scattering from a rough surface is contrasted with bouncing a ball on the ground. Suppose you are holding a basketball and begin to dribble a basketball off the ground. Suppose the ground is comprised of a bed of rocks the size of ping-pong balls. The rocks will have a minimal effect on the trajectory of the ball because the basketball is much bigger than the bed of rocks. Now, as the size of the ball decreases, predicting the trajectory of the ball is much harder. Taking a bouncy ball the size of a ping-pong ball and bouncing it off the bed of rocks yields more complicated to predict trajectories. This complication is similarly found in waves and surface roughness.

Experimentation shows that creating mirrors void of roughness is impossible. The precision of instruments used in the generation process

can be precise, but a perfectly flat surface is simply a computational aspiration. Understanding the effects of roughness on reflection is key to improving optical instruments. This has motivated a series of studies that have attempted to address how roughness affects reflection.⁶

Scalar correction factors are the most common way to handle surface roughness in recent work.^{7,8} Scalar correction factors take the reflectance value from a flat surface and multiply it by some factor used to account for the roughness. In general, they take on the form

$$R = R_0 C,$$

where R is the reflected intensity, R_0 is the calculated reflected intensity off a flat surface, and C is the correction factor. Correction factors of this nature are created from a myriad of things: root mean square (rms) roughness height from the surface, h ; the angle of the incident beam, Θ ; and the material properties such as index of refraction (see Fig. 1). The most common correction factors are Debye-Waller (DW) and Nevot-Croce (NC).^{9,10,11} Debye-Waller is most applicable to this project and is given by

$$R = R_0 e^{-4q^2 h^2},$$

where q is the momentum perpendicular to the surface of the incident beam and h is the rms roughness. The value of q contains the wavenumber and the angle of the incident beam of light. The rms roughness height h is a measure of how much the surface deviates from the flat surface. The value is calculated by taking the differences in heights from the actual mirror and a flat surface across multiple points across the mirrors and squaring them. These differences describe the average deviation of the mirror across the surface. Directly solving for the reflectance provides a comparison and analysis of the accuracy and precision of the scalar factors.

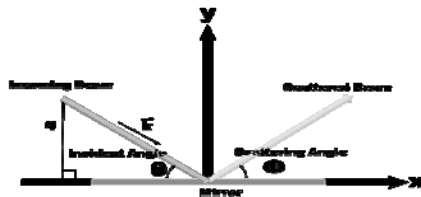


Fig 1: Depiction of the setup used for correction factors and for this project. For the specific case of Debye-Waller, k is the wavevector of the incoming beam, q is the momentum of the incident beam perpendicular to the mirror, Θ is the incident angle, and Φ is the angle of the scattered wave.

2 Procedure

Our computational model to calculate reflectance contains three parts. The model of the incident wave and its features comes first. Second, the modeled mirror is generated. The final element is putting it all together to calculate the overall reflection which is defined by outgoing spherical waves. Figure 2 shows the relationship between each of these elements.

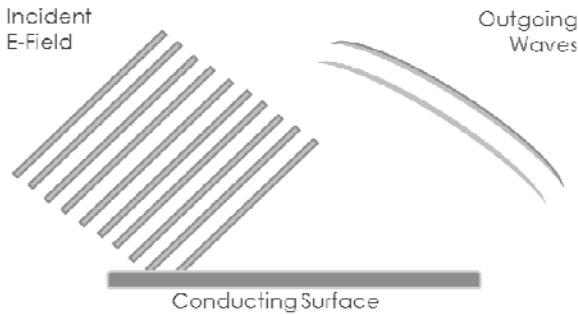


Fig 2: Setup of incident beam, outgoing spherical wave, and surface current diagram

The incident beam of light is modeled as an electromagnetic wave. The beam of light contains oscillating electric fields that collide with the surface of the mirror. During the process, the charges on the mirror vibrate resulting in induced surface currents. The incoming beam bounces off the surface in multiple directions resulting in a spherical wave. The generated spherical wave is the result of constructive and destructive interference of the reflected light created by incident beam and the induced surface current, both of which are modeled for impact on the outgoing wave. The inference pattern generated from the surface depends greatly on the roughness.¹²

Generating the surface contains two main parts: randomly generating mirror heights at discrete locations on the mirror and interpolating over them to create a continuous mirror surface. The surface is broken up into evenly spaced discretized points across the surface. Each point is given an x value representing its location across the surface and a corresponding y value that shows the height of the surface at this location. Different surfaces can be generated simply by altering the heights across the surface. These discrete points are then spliced together using splines of cubic polynomial order. These splines take a few points at a time to generate a fit for those points. This is done across the surface,

and each function is patched together similar to a piece-wise function. Now the surface model is continuous and better represents a real surface.

A realistic surface is random in nature. However, picking a random seed and generating random values for the y vector falls short of modeling realistic surfaces. A power spectral density of an actual mirror designed by the Turley-Allred research group is given in Figure 3. This diagram shows the energy-dependent frequency spectrum of the surface of the mirror. The figure shows that discrete frequencies are good models for matching the structure of real mirrors. Thus, to model these mirrors more realistically, two parameters will be considered, rms height and spatial frequency. The rms roughness height is the average deviation mentioned earlier and the spatial frequency is the number of completed periods per wavelength across the mirror.

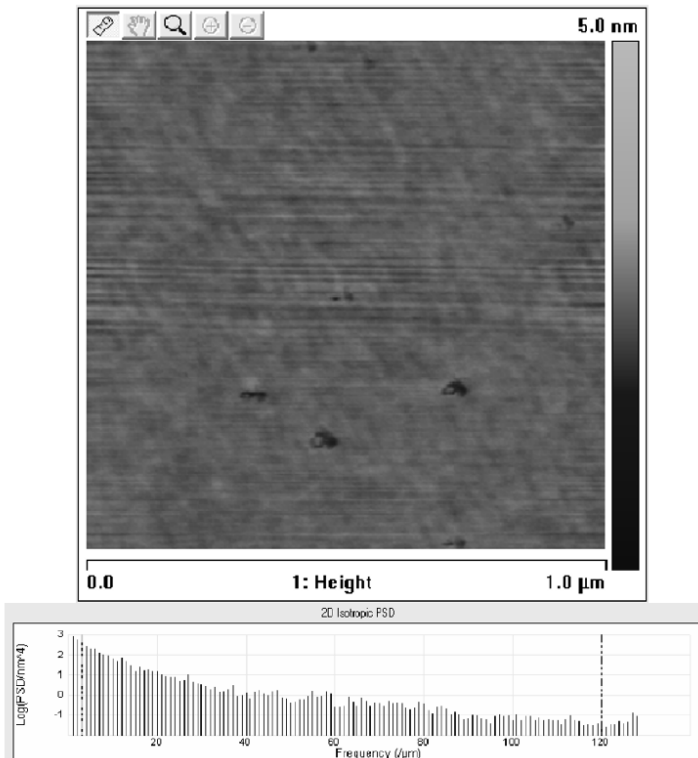


Fig 3: A mirror used in the laboratory for extreme ultraviolet reflectance along with the power spectrum. The power spectrum shows discrete frequencies across the surface. The overall spectrum is similar in shape to a Gaussian function.

To calculate the reflection of the beam we use electric and magnetic field boundary integral equations derived from Maxwell's equations. These equations are solved using numerical integration¹³ combined with Nystrom integration.¹⁴ We alter the rms height and spatial frequency to determine the effects each has on reflection.

3 Analysis

Two key surface parameters are adjusted to show their overall effect on roughness, namely, rms roughness and spatial frequency cutoff. When studying the effects that each parameter has on reflection, the other is held constant to isolate the influence to solely the altered parameter.

As seen in Figure 4, the effects of rms roughness have a direct impact on the reflectance. The roughness used in these graphs range from 0.01λ to 0.05λ . The left graph displays the log of the reflectance of the different outgoing angles and the right resembles the raw observed intensity. In both graphs the spatial frequency was held constant at $\frac{1}{4}\lambda^{-1}$ and the incident angle was chosen to be 40 degrees. These graphs show that at 0.03λ the intensity of the main peak loses about 10%, and as the rms roughness reaches 0.05λ , the peak reflectance is reduced by 20%. Looking at the logarithmic plot on the left, as the rms roughness increased, the secondary peaks gained intensity. Thus, as the main peak reflectance decreases, light is not lost but simply scattered at different angles.

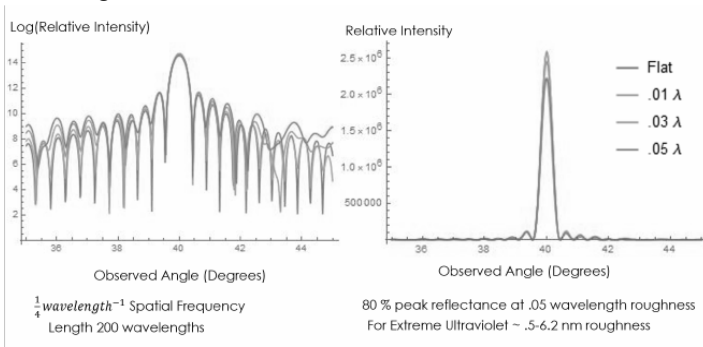


Fig 4: Reflection from different extreme rms roughness of an incident beam of grazing angle 40 degrees. Each surface has same surface length and spatial frequency as labeled in the figure. The left graph shows a logarithmic plot of the intensity, and the right shows the unaltered intensity.

Altering spatial frequency had a similar effect on reflection as rms roughness. Figure 5 shows that, as the spatial frequency decreases, the peak reflectance likewise decreased. In the graph on the left, the secondary peak increased, which shows that light was not lost but simply scattered to further angles. Thus, increasing the scale length of spatial variation minimizes the effects of roughness for a given rms roughness.

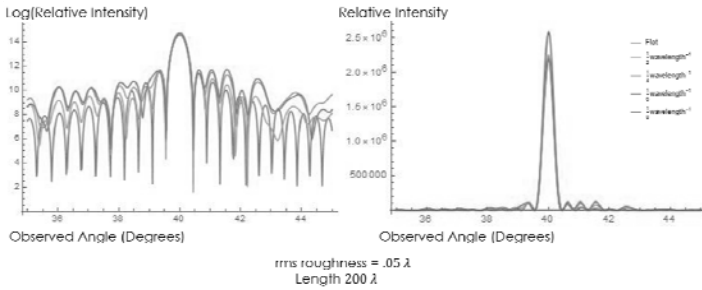


Fig 5: Reflection from varying the spatial frequency on the surface from an incident beam with grazing angle of 40 degrees. Each surface has same surface length and rms roughness as labeled in the figure. The left graph shows a logarithmic plot of the intensity, and the right shows the unaltered intensity.

4 Discussion

The effects of rms roughness are provided by Figure 4. Using the flat surface as a baseline comparison, the magnitude of the peak shows the loss of reflection due to increasing rms roughness. The curve showing 0.01λ depicts a subtle alteration to the peak reflectance. After increasing the roughness to 0.05λ , a greater dip in peak reflectance is seen. The loss of peak reflectance at this wavelength hangs around 20%, which is quite substantial in most experiments. Thus, the threshold where roughness effects are seen falls between 0.01λ and 0.05λ .

Collecting reflectance data over multiple incident angles and rms roughness of randomly generated surfaces provides a comparison to the Debye-Waller (DW) correction factor. The DW correction factor proposes the key characteristic of surface roughness is the qh value. This value is comprised of the perpendicular moment transfer, q , and the rms roughness height, h . To make an effective comparison, the qh value is used as the plotting parameter. The results are found in Figure 6.

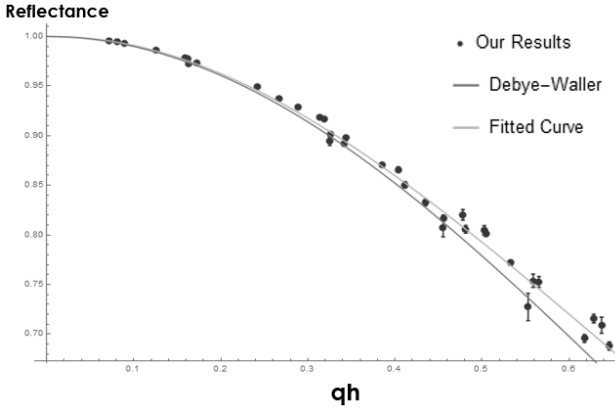


Fig 6: Comparison of data to Debye-Waller correction factor. The qh value is the momentum transfer multiplied by the rms roughness height. Random height and incident angles were chosen and the resulting reflectance is recorded.

Figure 6 provides insight into the accuracy of the DW correction factor. The organized clustering of the data suggests the qh value is an accurate parameter to characterize mirrors. The data were generated using random incident angles and rms roughness but all seem to follow according to the qh value. Our data support the appropriateness of the qh value as a defining characteristic of the effects of roughness. The DW model matches the data at small values of qh ; however, as qh increases, the model deviates from the data. The error bars suggest greater variance as qh increases.

Fitting the experimental data suggests additional correction terms beyond the quadratic. The DW correction factor solely uses the quadratic term to model reflectance. The weighted fit of our data suggests the following correction:

$$R = R_0 e^{\alpha qh + \beta (qh)^2 + \gamma (qh)^3}$$

where

$$\begin{aligned}\alpha &= 0.0146 \pm 0.0046, \\ \beta &= -1.06 \pm 0.0464, \\ \gamma &= 0.223 \pm 0.0944\end{aligned}$$

The values of α , β , and γ represent the linear, quadratic, and cubic terms, respectively. The DW model proposes the quadratic term is the sole contributor to roughness. The value of the quadratic term of the

DW correction factor is negative one. The relative small errors of all three terms validate their contribution. Additional terms beyond the cubic yielded statistically insignificant p values. Thus, the linear, quadratic, and cubic terms were the only terms presented in depth.

Repeating the calculation for surfaces having different spatial frequencies reveals the sensitivity of spatial frequency to reflectance. Figure 7 shows a change in peak reflectance as the spatial frequency is adjusted. Figure 7 shows the results of calculating reflectance from three different spatial frequencies, $\frac{2}{5}\lambda^{-1}$, $1\lambda^{-1}$, and $\frac{1}{50}\lambda^{-1}$. The inci-

dent angle and rms roughness height were also adjusted to provide a range of qh values. Figure 7a shows the error bars of the data points and Figure 7b depicts the fits for each spatial frequency. The $\frac{1}{50}\lambda^{-1}$ is the low-frequency extreme case. The error bars of this frequency are relatively large. This suggests an increase in variance as the frequency decreases. The $1\lambda^{-1}$ frequency, on the contrary, is the high-frequency extreme. The error bars in this case are relatively small thus suggesting minimal variance. The fit lines in Figure 7b depict the effects of adjusting the spatial frequency, and the disparity in each curve emphasizes the accuracy of spatial frequency as a surface characteristic.

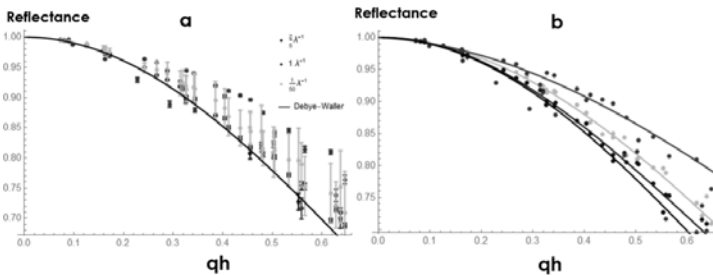


Fig 7: Reflectance calculations from three different spatial frequencies. The error bar (a) and the fits (b) are depicted for the same set of data. The Debye-Waller correction is also plotted for comparison. The spacing between fit lines suggests spatial frequency is an important parameter to consider in determining reflectance from roughness

5 Conclusion

The computational model used in this experiment provides an accurate simulation of the interference effects roughness plays on monochromatic light in one dimension. The model assumes a smooth Gaussian surface very similar to mirrors experimentally constructed in

the laboratory. In addition, the solving method makes no physical approximation by solving Maxwell's differential equations exactly. The factor inhibiting the precision is not found in the physics but rather in the precision of the discretization across the surface. The calculation assumes the roughness and surface current can be represented by discrete points across the surface. The computational approximation improves as the separation distance between points decreases, and in the limit this separation distance approaches zero, the approximation becomes perfect. This separation distance was modeled, and 20 points per spatial wavelength were used. Under the conditions of this model, 20 points per spatial wavelength proved to be an effective threshold where insignificant precision was gained by reducing the separation distance. A higher fidelity model is not found by improving the electromagnetic calculation but by decreasing the discretization distance creating a more continuous surface. This is implemented using superior quality computational equipment.

The results of our model generally promote the DW correction factor in a wide range of roughness but suggest additional parameters to further the precision as roughness becomes more extreme. Our data support the appropriateness of the perpendicular moment transfer and the rms roughness together, qh , as a defining characteristic of the effects of roughness. Our model successfully recovers DW in regimes where their quadratic term dominates, while the linear and cubic terms we introduce account for deviations from DW at higher qh values. The linear and cubic terms in our fit help account for the data at higher qh values. In the absence of these two terms, the precision falls off quickly as the qh value increases, suggesting that more terms are needed to model the effects of reflectance.

The spatial frequency results show there are more parameters besides rms roughness that affect reflection. Thus, correction factors like DW and others that similarly limit the included parameters in their correction fall short of accurately modeling the effects of roughness. Other current studies make similar assertions in developing proper correction factors. Stearns¹⁵ used different geometries of similar rms roughness and found equivalent results. Stearns proposed that the geometry of the surface contributes to the correction for roughness. Spatial frequency, as used in our experiment, is a systematic method to altering the spatial geometry. Our results in Figure 7 agree well with those of Stearns insofar that our steepest reflectance curves correspond to lower frequencies. Thus, rms roughness is not the sole parameter to formulate an accurate correction factor.

References

1. P. W. Wachulak, A. Torrisi, A. Bartnik, L. Wegrzynski, T. Fok, and H. Fiedorowicz, "A desktop extreme ultraviolet microscope based on a compact laser-plasma light source," *Appl. Phys. B*: 123, 25 (2017).
2. P. Naulleau, C. N. Anderson, W. Chao, K. A. Goldberg, E. Gullikson, F. Salmassi, and A. Wojdyla, "Ultrahigh efficiency EUV contact-hole printing with chromeless phase shift mask," *Proc SPIE*, 9984, Photomask Japan 2016: XXIII Symposium on Photomask and Next-Generation Lithography Mask Technology, 99840P (10 May 2016).
3. D. D. Allred, M. B. Squires, R. S. Turley, W. Cash, and A. Shipley, "Highly reflective uranium mirrors for astrophysical applications," *Proc. SPIE* 4782, 212-223 (2002).
4. A. Rockwood, "Creating realistic models of rough surfaces," Thesis, Brigham Young University, Provo, UT (2006).
5. S. Keller, "Rough surface modeling which removes high frequency components," Thesis, Brigham Young University, Provo, UT (2011)
6. J.E.J. Johnson, "Computationally modeling the effects of surface roughness on soft x ray multilayer reflectors," Masters Thesis, Brigham Young University, Provo, UT (2006).
7. J. K. V. Holy and I. Ohlidal, "X-ray reflection from rough layered systems," *Phys. Rev. B* 47, 15896–903 (1993).
8. B. P. L. Nevot and J. Corno, "Characterization of X-UV multilayers by grazing incidence X-ray reflectometry," *Revue Phys. Appl.* 23,1675-1686 (1988).
9. P. Debye, "Interference of Roentgen rays and heat motion," *Ann. Phys (Leipzig)* 43, 49-95 (1914).
10. P. Croce and L. Nevot, "Étude des couches minces et des surfaces par réflexion rasante, spéculaire ou diffuse, de rayons X," *J. Rev. Phys. Appl (Paris)* 11, 113-125 (1976).

11. Debye, P. "Interferenz von Röntgenstrahlen und Wärmebewegung." *Ann. Phys.* 348(1): 49–92 (1913)
12. D. J. Griffiths, *Introduction to Electrodynamics*, 4 ed. (Pearson, Harlow, Essex, UK, 2014), pp. 146–153.
13. J. Stewart, *Calculus*, 7 ed. (Cengage Learning EMEA, Andover, Hampshire, UK, 2008), pp. 538–539.
14. E. J. Nystrom, "Über Die Praktische Auflösung von Integralgleichungen mit Anwendungen auf Randwertaufgaben," *Acta Math.* 54, 185–204 (1930).
15. D. G. Stearns, "Scattering of x rays from nonideal multilayer structures," *J. Appl. Phys.* 65, 491–506 (1989).

Smoothed Particle Hydrodynamics Simulations of Proto-Planetary Collisions in the Early Solar System

Brandon K. Wiggins and Morgan Taylor
Southern Utah University

Abstract

A key prerequisite for the rise of life on Earth is carbon abundance in Earth's crust. However, it is expected that carbon and other volatile elements would either have boiled out of early Earth's atmosphere or else have been trapped within its iron core. Some have suggested that Earth's volatile elements including carbon were replenished through geologic history by comets and asteroids, but silver, copper, and carbon isotopic abundances on Earth disagree with the composition of these solar system bodies. Other theories suggest that most of Earth's carbon was delivered earlier on. It has been proposed that a collision with a Mercury-like planetesimal in the early solar system may have delivered much of the carbon in Earth's mantle and crust. This theory suggests that if sufficient sulfur was delivered to Earth's core in this merger, carbon sequestration into the core would be stymied, better allowing carbon to be convected to Earth's crust. In this paper, we simulate collisions taking place between a proto-Earth and a Mercury-like object with different speeds and impact parameters to explore the

conditions where such an impact would mix the impactor's and proto-Earth's cores. Our smoothed particle hydrodynamic simulations offer a computational fluid dynamics perspective on the proposed scenario.

Introduction

Questions continue to surround the geologic conditions that led to the rise of life on Earth. It is crucial that carbon be abundant in Earth's crust for the creation of organic molecules, but its presence poses a standing puzzle. Under conditions of high heat and pressure, including those in Earth's mantle during initial segregation, carbon can become "siderophile" or "iron-loving." This means that carbon will dissolve in molten iron and will be sequestered into Earth's core. Additionally, carbon is a volatile element that evaporates from Earth's atmosphere. If only these processes are at work, Earth's mantle should contain 1–4.5 parts per million carbon after Earth separated into a distinct core and mantle (Dasgupta et al. 2013) provided Earth was formed with carbon abundances typical for solar system bodies. This figure disagrees with the comparatively high measured values of the present mantle at ~35–115 parts per million (Rosenthal et al. 2015), suggesting that only small amounts, ~1%, of Earth's carbon in its mantle was also present during very early accretion. An additional source of carbon is required to explain Earth's observed elemental abundances.

When the Sun was forming, a disk of gas and dust surrounded the young protostar. Some of this disk material fell into the young Sun, but much of it was left in orbit. The remaining material gathered together to form objects such as planets, moons, asteroids, comets, etc. This period of planet formation was extremely chaotic. As certain bodies gather surrounding dust and gas, their respective gravitational influence increases. The material in the disk, including other growing bodies called planetesimals, was then pulled, not just by the Sun, but by other massive objects, which in turn altered their orbits. In this chaotic environment, early planetesimal collisions were probable and even expected, with many solar system abundance anomalies being explained by giant impacts.

One hypothesis proposes that carbon abundances in Earth's crust could be explained by the bombardment of carbon-rich asteroids or comets throughout Earth's history. In this way, carbon is replenished as geologic processes or carbon evaporation remove it from the crust. This is called the *Late Veneer* hypothesis. It is primarily challenged by differences in isotopic abundances of sulfur, silver, copper, and carbon in Earth's mantle compared with asteroids (e.g., Bernard et al. 2016).

Competing models propose that carbon was delivered to Earth much earlier, but the particulars of this delivery have yet to be pinned down. Li et al. (2016) proposed that a giant collision took place during the accretion (or early formation) phase of Earth with a carbon/sulfur-rich Mercury-like object in the early solar system as a means of delivering carbon but also mitigating carbon trapping in Earth's core. Mercury has high surface abundance ratios of K/Th (potassium to thorium) and K/U (potassium to uranium) as well as high relative sulfur abundances for solar system bodies (McCubbin et al. 2012). These clues suggest that Mercury possesses an iron core that is saturated in sulfur (Malavergne et al. 2010). If the early Earth were to sustain a collision with a similar object, Li et al. propose the loss of carbon from Earth's mantle to its core could be stymied. Li et al.'s laboratory experiments demonstrate that a sufficient concentration of sulfur in molten iron suppresses its affinity for carbon. In addition, the authors propose the impacting body may have possessed a carbon-rich mantle. Presumably, the impactor's carbon-rich mantle would mix with the proto-Earth's mantle, supplying it with the volatile element abundances observed. This theory relies on successful delivery of the Mercury-like object's core to Earth's core and subsequent mixing of the two object's mantles and cores. Although their proposal is intriguing, no hydrodynamic calculations exist to explore which conditions are necessary to produce this result.

In this short paper, we explore this scenario by carrying out a small set of parallel hydrodynamic calculations using a simple hydrodynamics scheme called smoothed particle hydrodynamics (SPH). We seek to determine conditions in which major mergers between planetesimals merge cores and mantles.

Methods

SPH is a numerical method that solves the Lagrangian equations for fluid dynamics. In Lagrangian fluid formulations, the fluid equation is solved in the frame of the fluid, and the computer advances the positions of mass elements. This is distinct from Eulerian schemes, which solve the fluid equations on a static grid. With this latter method, the evolution of the fluid is followed as mass or other quantities are advected between cells. Lagrangian schemes contain pleasing properties of explicit mass and momentum conservation, rendering them ideal for collision calculations. It should be noted that although we use the term *hydrodynamics*, these models are appropriate for modelling solids and gases, although in some cases additional physics is required, e.g., fracture and stress. We ignore material strength physics, a practice common in planetary collision calculations. This is possible because the fluid

equations are simple statements of conservation laws of mass, energy, and momentum, all of which still apply to matter in various states.

SPH takes fluids and *discretizes* them, or splits them into numerous small pieces, and then applies the conservation laws to each piece. Because the fluid is understood to be continuous, SPH then “smears” the pieces of a region of space with weighting functions or smoothing kernels. The conservation laws that are applied to each piece of the fluid implicitly state the “rules” of how each of the millions of particles in the simulation will behave. For a general audience, we qualitatively describe these behaviors here:

1. As the fluid expands, or as particles move away from each other, density decreases.
2. Fluid pressure is related to fluid density, composition, and temperature, a relationship defined by an “equation of state” (EOS).
3. Parcels of fluid accelerate from regions of high to low pressure. In our calculations, we neglect the effects of rotation, which would give rise to geostrophic flows.
4. As a fluid adiabatically expands or contracts, its internal energy diminishes or increases respectively.

In this paper, we use classic SPH with self-gravity with standard values of artificial viscosity. In particular, we use SNSPH (Fryer et al. 2006), which utilizes a powerful Hashed-Octree (Warren & Salmon 1993) framework for accelerating neighbor searches and for calculating the gravitational force on each particle due to the influence of all other particles in the simulation. We implemented a simple planet EOS for iron and silicates (Seager et al. 2007). We do not implement strength, fracture, or damage and focus solely on hydrodynamics. All calculations were carried out on Los Alamos National Laboratory Turquoise Network Platform Wolf under Institutional Computing allocations.

Initial conditions were generated via a shooting method solving the equations of hydrostatic equilibrium in spherical symmetry. For simplicity, we compose our planets of only iron for the cores and MgSiO_3 for the mantles, and we use the analytic equations of state in Seager et al. (2007). We produce an approximately Earth-mass body and a Mercury-mass body with iron core radii consistent with observation. These radial profiles are converted into 3-D particle distributions via a Weighted Voronoi Tessellation code (Diehl et al. 2015), which produces particle positions that do not give rise to disturbances on scales smaller than a smoothing length. Even so, we relax each planetesimal in isolation inside SNSPH so that all disturbances in our collision calculations arise from merging the two planets. Each colli-

sion simulation uses ~ 1.5 million equal-mass particles. Particles represent either iron or MgSiO_3 . Because iron is more dense than the silicates that make up the mantle, iron particles are more densely packed in the simulation volume (Figure 1).

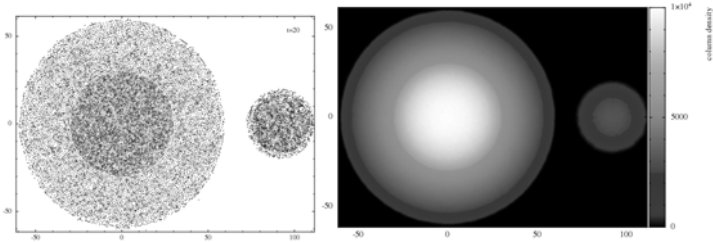


Figure 1: *Left:* Cross-section of particle position initial conditions for an impact parameter = 0 calculation. All particles are equal mass, and the sudden increase in particle density corresponds to the location of the iron core. Note that the Mercury-like object is mostly iron-core as observed. *Right:* Volume render of rock column density for particle position in the left panel. Distances and densities are plotted in code units (1 length unit is $1.0e7$ cm and 1 code density unit is 0.1 g/ml).

In this study, we vary impact parameter and impact speed and assume the frame of the Earth-like body for convenience. In many similar calculations by other authors, a center of mass frame is assumed. Our impactor is 5% the mass of our Earth-like body, our fluid formalism is Lagrangian, and our planetesimals are not rotating and so our results are independent of chosen frame. We carry out 9 simulations in a small 3×3 grid, varying impact parameter as 0, 0.5, and 1.0 earth radius. Impact speed is varied at 25, 50, and 100 km/s, which seems to bracket likely collision speeds between planetesimals in the early solar system. Each run requires ~ 24 hours on 256 processors. We visualize our results in SPLASH (Price 2007).

The goal of this study is to explore over this small set of 9 simulations the dynamics of collisions proposed by the authors and to gain some insight into how easily iron cores between an Earth-like body and a Mercury-like planetesimal are likely to merge and mix from collision dynamics.

Results and Discussion

All of our calculations are highly energetic impacts, which leaves the scenario of slower relative velocities and impacts with rotation for another study. All of our calculations reveal substantial upheaval to

planet structure, but the total energy of the system remains much less than 0 for all our calculations, indicating that merged planetesimals are, by and large, gravitationally bound.

We discuss simulations with 0 impact parameter first (i.e., “head-on” collisions). In the 50 km/s run, impact of the Mercury-like object compresses silicates ahead of it in the Earth-like object and the kinetic energy of the impactor is transformed into internal energy. A shockwave is produced that propagates through the interior of the planet in ~ 1000 s in agreement with the speeds of seismic waves through the interior of Earth ($\sim 8\text{--}13$ km/s). As expected, the shock travels *slower* through the iron core than the silicate mantle as kinetic energy of the shockwave is transformed into thermal energy more efficiently. As the shockwave travels through the planet, it heats material behinds it, which later performs PdV work and re-expands. The impact ejects portions of Earth’s and the Mercury-like body’s silicate mantles into space.

The collisions we have modeled in this paper involve high relative velocities, and our calculations only follow the evolution of the collision out to ~ 20 minutes. This time is assumed to be substantially smaller than the rotation period of the Earth-body, so we don’t expect the effects of rotation to play a major role in the dynamics of the collision over the time scale of our simulations.

The shockwave is visible as a discontinuity in density in the upper panels of Figure 2. The heating of the interior of Earth and the impactor is visible in the lower panels of the same figure. The ejecta remain hot out to late times and the shock-heating in the planet interior cools behind the shock after re-expansion. Our code does not take into account heat conduction, or radiative cooling, effects, which we assume are small. This means that full convective heat transfer facilitated by heat conduction does not occur in our simulations. Thus, large values of internal energy roughly trace high levels of compression with the exception of the low-density ejecta.

In our calculations, the mantle ahead of the impactor is *compressed* and not squeezed to either side as the impactor pushes into Earth (see the very bright regions ahead of the impactor in the lower panels of Figure 2). A thin membrane of mantle remains between the cores out to late times as shown in Figure 3. If this result is to be believed, it would suggest that the two cores do not mix as a direct result of impact dynamics. For the hypothesis in Li et al. (2016) to hold, carbon in the impactor’s core must be mixed through subsequent processes, perhaps on much longer time scales than that of the impact.

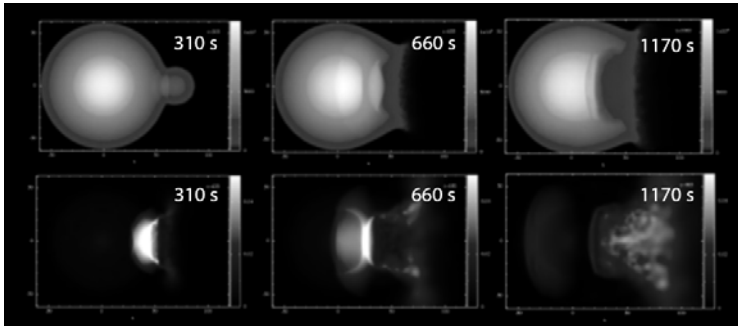


Figure 2: *Upper panels:* Column density of impact at several stages. Column densities are reported in code units (1 density unit is 0.1 g/cc). *Lower panels:* Internal energy integrated along the direction parallel to the line of sight.

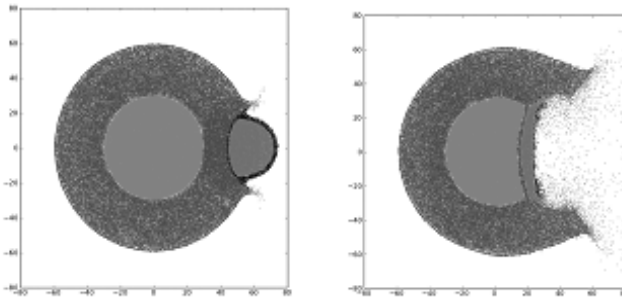


Figure 3: Our calculations do not predict extensive mixing of the two planetary cores. Above we plot particle positions for an equatorial cross-section for impact parameter 0, with the Mercury-like planetesimal impacting Earth at 50 km/s at early and late times in the impact. Lighter shaded particles are Earth's sulfur-poor and the Mercury-like impactor's sulfur-rich iron core, respectively. Darker shaded particles are Earth's carbon-poor mantle and the Mercury-like impactor's carbon-rich mantles, respectively. The cores and mantles do not merge and mix homogeneously on the timescales of our calculation.

There may be reasons to be skeptical of this result. SPH calculations can suffer from an artificial surface tension at contact discontinuities, which can impair the growth of instabilities and mixing between differing materials (e.g., Agertz et al. 2007). Utilizing additional hydrodynamics schemes may shed light on the sensitivity of our results to this possible limitation with SPH. Nevertheless, our work already suggests that delivering sulfur to Earth's core directly via giant impact may

be less straightforward than Li *et al.* (2016) suggest. Additional processes not captured in our calculation such as angular momentum, perhaps acting on time scales much longer than that of the impact, may be required to mix the cores because the desired mixing is not predicted by our simple hydrodynamics model. This failure to mix, however, could stem from very physical effects such as the speed and size of the impactor: the compressional wave travels sufficiently fast so that the mantle between the cores is not effectively squeezed from between the bodies and becomes trapped within the flattening interface of the two cores.

As a general trend, we also observe minimal mixing of even the mantles. During the merger, a reverse shock ejects the backside of the Mercury-like planetesimal's mantle, which leaves the system in a hot, expanding plume. In our setups, our Mercury-like planetesimal is composed mostly of its core, as is the case for Mercury. Li *et al.* (2016) do not specify a core-to-mantle ratio, although results might differ if this is allowed to vary. We observe mixing of the mantles in the rarefied medium in the wake of the impactor. Perhaps fallback and reaccretion of the ejected material at late times mixes the mantles, but our calculations do not follow the merger out to these events. Our simulations also do not take into account rotation of the individual bodies, which might also serve to mix cores and mantles during fallback, but for now we consider these effects to lie beyond the scope of this pilot study.

Do larger impact energies change the story? Our calculation for a 0-impact parameter collision taking place at 100 km/s initially appears to produce the desired results of merging the cores and mantles of the two objects together (Figure 4), although remnants of a thin film of mantle between the cores is evident for much of the calculation. Near the end of the simulation though, as seen in the last panel of Figure 4,

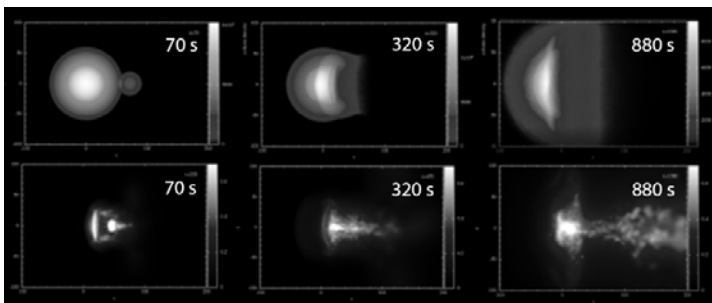


Figure 4: Same as Figure 2, but for the 100 km/s impact with zero impact parameter (head-on collision). Note the destructive aftermath of the collision.

the material does not settle back into a planetary form, and we seem to have produced an explosion. Because total energies for most all of the particles in the system are negative, we expect the planet to recollect at a time much later than ~ 1000 s or ~ 30 min, which is the approximate physical time represented by our calculations. Of our simulations, this setup appears to offer the most favorable results under the expectation of fallback and restratification of the body, although we note that relative speeds of ~ 100 km/s run high for that expected between bodies even in the chaotic dynamics of the early solar system.

Larger values for impact parameter do not change our results meaningfully. The cores of the planets continue to fail to mix as a direct result of collision dynamics (Figures 5, 6, and 7). With a very large impact parameter, the cores do not come into contact and the impactor is essentially shredded in the ordeal (Figure 7). The sulfur-rich core of the impactor would only be able to transition to the core of the proto-Earth via gradual segregation, which may or may not be helpful for trapping carbon in the mantle.

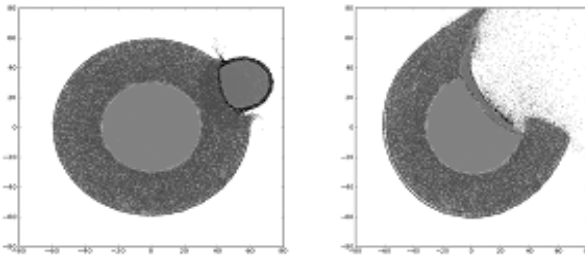


Figure 5: Particle positions colored by material type for the 50 km/s collision with impact parameter $1/3$ an earth radius. Lighter shaded particles are the cores of the respective bodies and darker shaded are the MgSiO_3 mantles.

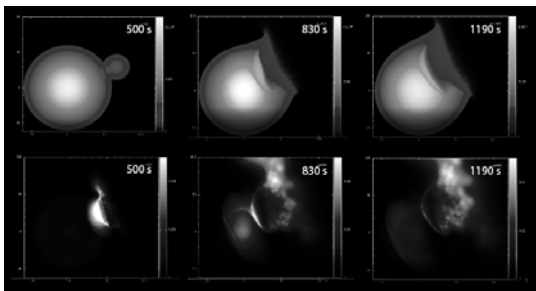


Figure 6: Same as Figure 2 but for the 50 km/s collision with impact parameter $1/3$ an earth radius.

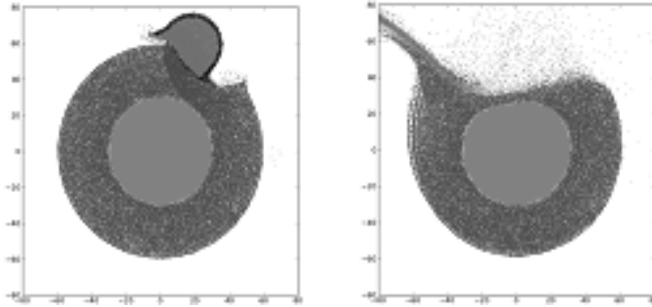


Figure 7: Same as Figures 3 and 5 but for the collision with an impact parameter equal to an earth radius occurring at 50 km/s. The cores of the planetesimals do not come into contact as the Mercury-like body plows through the mantle of the young Earth-like body.

Conclusion

None of our calculations convincingly play out the scenario proposed in Li et al. (2016). In our small grid of 9 hydrodynamics simulations, planet cores do not merge and mix and mantles do not merge and mix on the time scale of the impact. Our calculations involve only Lagrangian hydrodynamics with planet (iron and silicate) equations of state and self-gravity, and we neglect fracture and strength physics. But even the inclusion of these effects is unlikely to affect our results on the scale of large, spherical planetesimals. Our best mixing occurs at very high impact velocities. In these calculations, cores merge somewhat successfully but leave a partially unbound Earth. The merger remnant will recollect and segregate, but our calculations only examine time scales of the impact itself, and longer calculations might be necessary to examine this issue.

In our calculations, cores may not have mixed because of numerical artificial surface tension, which can arise in SPH at contact discontinuities. This effect has been shown to suppress mixing in idealized turbulence fluid dynamics tests, but it is unclear to what extent this surface tension manifests itself in our scenario. An alternate code such as Athena (Stone et al. 2008) or Castro (Almgren et al. 2010), both Eulerian codes, might be better adapted to study details of the turbulent mixing. These calculations will also shed light on the sensitivity of our results to possible short-comings in mesh-free Lagrangian hydro schemes.

Future work will also involve creating a larger calculation grid and varying parameters over a few orders of magnitude. Rotational effects may affect mixing dynamics which is an effect we did not con-

sider here. Our difficulty in mixing cores and mantles of planetesimals via direct impact may have ramifications for giant impact theories during planetesimal accretion phase in the early solar system.

References

- Agertz, O., Moore, B., Stadel, J., et al. 2007, *MNRAS*, 380, 963
- Almgren, A.S., Beckner, V.E., Bell, J.B., et al. 2010, *ApJ*, 715, 1221
- Bernard, M., Guillaume, A., Yuji, S. et al. 2016, *Earth Planet. Sci. Lett.*, 411, 91
- Dasgupta, R., 2013, *Rev. Mineralog. Geochem.* 75, 183-229
- Diehl, S., Rockefeller, G., Fryer, C.L., Riethmiller, D., Statler, T.S. 2015, *Publ. Astron. Soc. Aust.*, 32, e048
- Fryer, C.L., Rockefeller, G., Warren, M. 2006, *ApJ*, 643, 292
- Li, Y., Dasgupta, R., Tsuno, K., Monteleone, B., Shimizu, N. 2016, *Nat Geosci*, 9, 781
- Malavergne, V., Toplis, M.J., Berthet, S. Jones, J. 2010. *Icarus* 206, 199–209
- McCubbin, F.M., Riner, M.A., Vander Kaaden, K.E., Burkemper, L.K. 2012. *Geophys. Res. Lett.*, 39, L09202
- Price, D.J. 2007, *Publ. Astron. Soc. Aust.*, 24, 159
- Rosenthal, A., Hauri, E.H., Hirschmann, M.M. 2015, *Earth Planet. Sci. Lett.*, 412, 77-87.
- Seager, S., Kuchner, M., Hier-Majumder, A., Militzer, B. 2007, *ApJ*, 669, 1279
- Stone, J.M., Gardiner, T.A., Teuben, P., Hawley, J.F., Simon, J.B. 2008. *ApJ*, 178, 137
- Warren, M., Salmon, J. K. 1993, *Proc. 1993 ACM/IEEE Conf. Supercomput.*, 12–21.

Veterans and the Department of Veterans Affairs

Catherine Stoddard, Barrett Bonella, and
Corina Segovia-Tadehara

Weber State University

Abstract

When military personnel return from their service, they often experience a variety of medical, psychological, financial, social, and educational needs that are generally met by the Department of Veterans Affairs (VA). The purpose of this study was to explore and consider what the VA system looked like from veterans' points of view and how the VA helped shape their own self-perceptions as veterans. Ten veterans were interviewed using a set of 25 questions relating to their military service, their understanding of the VA healthcare system, and their own experiences with the VA. The interviews were recorded, transcribed, and later analyzed with the help of the ATLAS.ti 7 program. Journals were also kept regularly to ensure objectivity, and self-reflection was accounted for throughout the study. Issues such as trust, experiences with the health care system, positive and negative interactions with all aspects of the agency, and perception of the veterans themselves as priorities of the government based on VA funding were discovered. The results indicate several areas in which the VA fails to challenge the belief that quality services for veterans are

available. Such failings are perceived to be results of antiquated policies, inflexible bureaucracy, and politically low prioritization of veterans after they have completed their part as service members.

The Department of Veterans Affairs (VA) is a government agency which provides benefits and services to the United States veterans. There are a variety of services provided to veterans by the VA, such as medical and mental health services, funds for education and vocational training, access to specific types of home mortgages in addition to disability and death benefits. Since the 1930s when the VA was created, there have been scandals based on corruption within its system, resulting in the mistreatment of veterans. To this day, veterans continue to struggle to receive deserved benefits from the VA, and adequate solutions to these problems have yet to be implemented (Druzin, 2015). It is crucial that American citizens know about problems this population is dealing with in regard to the VA system.

Literature Review

Former military members have access to funds to a full four-year college education under the new GI bill, which was expanded in 2009. A qualitative study regarding veterans' perceived barriers to a quality education was conducted by a team of researchers at the University of California located in San Diego. According to Norman et al. (2015), "The goal of this study was to further understand perceived facilitators and barriers of achieving academic goals among student Veterans using the GI bill" (p. 707). Results of the study indicated that mental and physical health issues were seen by veterans as immense obstacles in the way of achieving their academic goals. Additionally, some participants of the study suggested that they did not believe they had the skills to be successful with their academic goals. However, Norman et al. (2015) added, "Academic readiness classes are offered at certain VA facilities to assist veterans with preparing to go back to college and be successful with their goals" (p. 708). It was further indicated that academic success attained by veterans was a result of having campus resources, such as student service centers offering tutoring, academic advisement, and mental health counseling.

Perceptions differ among male and female veterans in regard to receiving mental health care. The results of a study conducted by a team of researchers revealed that perceptions varied between male and female veterans regarding the mental health services within the VA. That study was based on veterans who served in Operation Enduring

Freedom (OEF) and Operation Iraqi Freedom (OIF). Conclusions indicated there were a higher number of males who displayed negative views about the VA's mental health services than females. The researchers indicated that for both male and female veterans perceived entitlement to VA services increased the likelihood of seeking treatment (Fox et al., 2015).

Senior veterans have been shown to experience difficulties receiving quality emergency services while visiting hospitals and clinics. Hastings et al. (2013) conducted a study that revealed the VA's emergency services were affecting veterans ages 65 and older negatively. The results of the study revealed that the older veterans tended to have the most severe and chronic health problems, resulting in the VA having difficulties with administering emergency services. The conclusion indicated that the VA does not have enough resources to adequately treat health issues affecting this population. The researchers found that at least 20% of older veterans are treated and released from emergency services instead of being hospitalized when needed (Hastings et al., 2013). Finally, there is a perceived stigma attached to post-traumatic stress disorder (PTSD) and combat veterans' perceptions of seeking treatment. The methods of the study involved recruiting 16 OEF/OIF veterans who had been diagnosed with PTSD in a "convenience sampling strategy that included focus groups" (Mittal et al., 2013). Results indicated veterans had concerns about receiving a label of mental illness as one factor that impeded help seeking in the early phases of re-adjustment to civilian life (Mittal et al., 2013). As cited by Mitall et al., additional research revealed active-duty soldiers also feared the diagnosis of PTSD because they did not want to be seen as incompetent by their superiors (Hoge et al., 2004).

Methods

The purpose of this study was to investigate deeper the perceptions that veterans have of the VA. Those perceptions, regardless of the facts about the VA's services, influence the decisions of veterans when it comes to how they choose to use or not use the services made available to them. The study was designed to be broad in its focus, leading to new questions upon which further research studies can be brought forward. As such, veterans are defined broadly to include members of any armed forces who have spent any time on active duty in the military. The VA itself is also a multifaceted bureaucracy offering many services beyond medical care, with many such areas deserving of specific inquiry.

The paradigm of participatory action-based research was used for this study. Through this type of research, the populations studied were encouraged to voice their perceptions and beliefs of their life circumstances. There was a huge emphasis on stakeholders in the studied population acting as co-researchers assisting the principle researcher with all aspects of the project. Action-based research is derived from the theory that researchers must immerse themselves into the study by means of participation within the community being studied (Yin, 2016, p. 68). Through this process, the researcher was able to conceptualize meanings behind messages received on a deeper level, enabling the accuracy reflecting thoughts, beliefs, and experiences of the population being studied.

All research conducted for this study was performed on the campus of Weber State University (WSU) in Ogden, Utah, over a period of three months. The questions used for the study were approved by the Institutional Review Board at WSU, and consent forms were signed by each participant before interviews were performed. Following the theory of participatory action research, a participant guide in the study was a fellow student and Vietnam veteran who has been dealing with the VA for most of his life. He was also completing his bachelor-level internship at the Department of Veterans Affairs in Salt Lake City, Utah, during the time the study took place. Because he knew many veterans on campus, he was able to assist immensely in the recruiting process of the interviewees. He was also one of the veterans interviewed and his efforts alone assisted with allocating and inviting interviewees, which lead to use of the snowball sampling method.

The snowball sampling method was conducted by means of interviewing one veteran and then asking them if they knew other veterans willing to participate, leading to additional interviewees. However, despite recruiting efforts on campus, only 10 volunteers were found to participate. It was preferred to find about five more participants, but time constraints on the project were a limitation in collecting a larger sample size. The only variable for a participant to qualify as a candidate for the study was service in any branch of the U.S. military, either previously or currently. The sample size included nine male veterans and one female veteran. Out of the 10 veterans interviewed, one served in Vietnam, one served in the Operation Desert Storm, and eight served in OEF and Operation Iraqi Freedom OIF. Despite the small sample size, it was diverse in terms of where participants had served.

In regard to data collection, all research was conducted on the WSU campus with current students. Interview questions were created based on general issues faced by veterans, and yielded a set of 25 questions. One form of data collection involved face-to-face interviews be-

ing conducted by use of an audio recorder and writing field notes. The second form, field triangulation, is a method used in qualitative research that involves more than one methodology to solidify validity of data gathered to answer the original research question (Yin, 2016). Field/triangulation notes were kept separate from interview dialogues for the purpose of assisting researchers to remain objective while analyzing data. In the case of this study, triangulation included attendance of a town hall meeting hosted by veterans at their student service building located on the WSU campus in addition to witnessing a Veterans' Day remembrance ceremony, also held on campus. During the town hall meeting, notes were taken on topics addressed in the agenda, such as parking issues on campus, testing services at WSU's Career Center, and campus upgrades.

In addition to having informal conversations with the participants, the Veteran Service Center had been visited a few times at this point to hand out flyers for advertisement of the study and to encourage recruitment. There was an observation made that there were never any female veterans involved at the center and none were present during the meeting either. There was a point made to ask about why there were no females, but none of the members would say much about this topic. Nevertheless, the opportunity presented itself for gathering further information, which was recorded in field notes. In regard to the remembrance ceremony, there were flags set up to represent all branches of the U.S. military, many candles were lit, music was played, and speeches were given by military personnel and their family members. There was no conversation at the ceremony; there was simply observation in silence.

The audio recordings were listened to repeatedly to gain a higher level of interpretation of messages that were given. The conversations were transcribed by listening to the recordings and typing them into written dialogues. After the transcription process, compiling data from interviews and notes was completed. The data was transferred into the ATLASTi 7 software program designed for organizing qualitative research information. The dissimilation procedure required going through all responses and notes and attaching analytic memos to them. Designated codes were assigned to the memos. Memos were gathered into themes, leading to interpretations. The interpretations uncovered underlying messages and meanings which lead to conclusions. Furthermore, conclusions were tied together, creating a hierarchical outline for final analysis.

It is worth noting in viewing the results that the study was intended to understand the perceptions of veterans of the VA. Those perceptions varied somewhat from the reality of the situations they faced,

as evidenced by additional studies contrasting our evidence (referenced below). Although the reality of VA services may be different from the perception, the perception of those services plays a strong role in determining whether or not veterans will seek services from the VA. Much of what they had to say about the services is likely biased, but as those stories spread through the veteran community, they tend to influence the veteran's beliefs about whether or not the VA system can be trusted.

Results

A dominating theme occurring throughout the study was the issue of trust. During observations, it appeared veterans were having difficulty trusting individuals within the VA, and they were seemingly cautious in trusting outsiders. Confidentiality was essential for the protection of participants, so they were not required to sign their real names on consent forms nor mention them during audio recordings. Despite assurances of privacy, two veterans stated relief in using pseudonyms and the rest signed with their first name and last initial. The participant guide stated "Veterans' struggle discussing issues about the VA to outsiders." There was an observation that many of the participants expressed fear that if information given during interviews got back to the VA, they might be punished in some form or another. Here is one example of how mistrust toward the VA affects some veterans: When asked whether emotional and mental health needs were being met by the VA, one interviewee expressed, "No, and I have not tried to receive mental health care for my anxiety because of my fear of some type of retaliation and the possibility of losing my current job within the military system."

In regard to trust with outsiders, it appeared the participant guide's assistance with interviews could have alleviated distrust and increased accuracy of information given. It was also discovered that war stories were shared more often in the guide's presence, and it appeared that veterans' comfort level increased and more intimate details were revealed. Veterans were not probed for information about war experiences and stories; they were freely given when the audio recorder was turned off.

Another prominent theme involved negative and positive views in addition to experiences veterans had with the VA's health care system. During discussions, it was noted that veterans' perceptions, either positive or negative, were based on personal experiences or rumors overheard by comrades. As the participant guide explained, "Veterans often share stories about their experiences with one another in regard to the

VA.” Here is an example of how rumors could cause damage to veterans which could affect preventative care, as one veteran stated, “I do not feel that the VA is proactive with providing health care, and I have not used the medical benefits because I am apprehensive about the time it would take for them to get me in to the doctor and seen.”

Rumors and/or stories spread among veterans seem to discourage some of them from seeking VA benefits, thinking that the point of doing so would be moot. This view could lead to negative outcomes for veterans, especially in regard to healthcare, because while they are waiting to receive physical or mental care, their health may deteriorate to the point where it is too late for treatments to improve it. Despite the negative views of the VA benefit system outweighing the positive, there was more positive feedback than originally anticipated. Furthermore, there was an underlying theme of humility and gratitude among the participants. Five of 10 vets indicated, in one way or another, that if they could summarize their experiences in one word or sentence, they would say that their experiences led them to becoming the people they are presently, and that they were grateful to have served their country.

It was also noted that participants who discussed having satisfaction with the health care system did not speak of personal health issues. Two out of 10 veterans had positive things to say about the VA health-care system. One stated, “I don't deal with the VA doctors, and I haven't needed to yet.” Another veteran expressed highly positive feedback about the VA's health care system and exclaimed, “I could get hit by a bus and be torn to pieces, and they [the VA] would put me back together again for free.” However, veterans claiming to have a combination of mental and physical health issues expressed the most dissatisfaction with the VA's medical services. It appeared as though there was a correlation between health or lack of experience with the VA medical services and positive perspectives. On the other hand, there seemed to be a connection between poor health, extensive experience, and negative beliefs about VA medical services. Coming from a neutral perspective, one participant stated, “Veterans need to put the foot work into getting their benefits, and that they just can't expect them to be handed out.” The statement was interpreted to mean that while benefits are much deserved by many veterans, the VA is a complicated entity with many members, and, as with any other government agency, there are hoops to jump through to obtain needed services.

The most prevalent complaints about the VA's health care system were the issues of long waiting lists for obtaining medical care, and it was mentioned by eight of 10 veterans as being the worst aspect of the agency's health care system. One veteran exclaimed, “I feel like I am waiting to die for the second time.” Another interviewee stated, “Some

veterans die while waiting for healthcare and the VA to help them and would prefer it if we did die so they don't have to pay the money for our medical treatments.” Participants also indicated that during medical appointments, they were treated like numbers instead of human beings because of being rushed in and out of the office without a proper diagnosis or treatment. As yet another interviewee stated, “One doctor told me to take an aspirin, and I would feel better in a few days.” It turned out that he was experiencing the effects of a serious injury causing much more pain than a mere aspirin could alleviate. Additionally, it was stated by a participant that, “VA doctors tend to have a poor bedside manner, and they should provide more than two minutes for office visits.” The statements made were further explained by participants that VA doctors were trying to mask problems with pain medications rather than treating the underlying issues causing the pain in an effort to reduce costs for the government entity. Furthermore, it was discovered that six of 10 veterans mentioned experiencing one or more negative encounter with the health care system.

Telling as their perception of the service is, there is a contrast with recent research revealing evidence that the VA has improved outcomes and may even be outperforming other medical systems in the U.S. in terms of quality of care at both an inpatient and outpatient level (Oliver, 2007). On top of that, statistically there are fewer veterans than in previous years, and more of them are getting services than in the past (Bagalman, 2014). Such improvements over the last 10 years apparently had not gained traction in the narrative of those interviewed or were possibly overshadowed by previous experiences.

Another topic repeatedly mentioned was the rising numbers of veterans who are addicted to opiates. One veteran stated, in an angry tone, “Yeah, and vets are over- or under-medicated, and you get addicted to drugs there [the VA].” He also indicated that reasons behind abuse were related to VA doctors pushing opiates on to veterans for pain management without thoroughly diagnosing their underlying problems. Another participant provided more evidence of inadequate medical practices by stating, “Needed surgeries are not provided in a timely manner.” It would make sense as to why veterans are using high doses of opiates to alleviate pain because they are waiting for necessary surgical procedures, which only increases the chances of substance addiction among veterans. Furthermore, there are many types of opiates, and their synthetics cause individuals to go through long, unpleasant withdrawal processes, which would make it even more difficult for them to stop taking the drugs if desired.

The belief that the VA overprescribes opiates to veterans seems to be evidenced in the literature. Seal et al. (2012) found nearly three

times as many veterans were prescribed opiates if they had a mental illness, especially PTSD. Those who had PTSD were significantly more likely to be diagnosed with pain disorders, to get higher doses of opiates, to have two or more concurrent prescriptions for opiates, and to have a concurrent prescription for hypnotics. Beyond these findings, they also found that receiving opiate prescriptions was associated with poor clinical outcomes, especially for those with PTSD. Those who had experienced substance use disorders in the past were also found more likely to misuse opiates, borrow others' prescriptions, and request early refills (Morasco & Dobscha, 2007).

Additional services provided by the VA include educational and mortgage benefits. Most veterans indicated the VA's financial aid benefits were efficiently meeting their educational needs. One participant stated, "Despite minor setbacks, the financial aid benefits were worth waiting for." However, another veteran had a different experience in regard to ways that the VA works with educational institutions and stated, "Education benefits are decent once they go through the VA process of approval. I feel like I have to fight through a bureaucracy to get through the process, not only with the VA, but also with Weber State's systems as well." Additionally, two veterans mentioned they received loans sponsored by the VA to purchase their homes. The veterans who commented on home loans specifically offered to military members had no complaints about their mortgage benefits, and one participant stated, "There are certain things when they do the inspections of the homes, the VA requires certain requirements in their inspections. So, I know I'm getting good things because the VA requires it."

In regard to disability services, they include both cash assistance and medical benefits; eight of 10 veterans stated that they had either a physical or mental disability due to injuries inflicted from combat situations. There were many statements made about disability benefits and waiting periods for obtaining approval. One of 10 veterans interviewed portrayed a positive perception of the VA's disability benefit system and stated, "It only took them [the VA] about eleven months, and that was a short waiting period compared to the average timeframe for receiving benefits." However, the other veterans complained of the long waiting periods after filing for disability benefits. This is a serious issue for some veterans and their families because in some cases they cannot work full time, or at all, because of injuries or illnesses sustained. One veteran indicated that he had to rely on public services to have all of his basic needs met, "I had to get help from a food pantry to feed my family while waiting for benefits."

The foci of complaints among interviewees zeroed in on the subject of proving disabilities and how difficult those processes are because of a lack of proper record keeping by military systems of injuries inflicted during battle. Also, there were numerous complaints from them about struggles of wading through mounds of paperwork and not knowing of, or having access to, a VA representative who could guide them through the complicated process. The results of such a situation could cause veterans to have to wait several months longer than they should have to receive their benefits.

The final theme includes suggestions made by veterans addressing their desires for change within the VA system. Improvements in the health care system were mentioned, such as shorter waiting lists and a higher quality of treatment. One participant stressed, "The agency's legal system needs to be overhauled." He also delved into details about politics within the system, exclaiming that positions of governing officials should be rotated more frequently while also creating limits on years in office. Additionally, he stated, "The agency should dispose of old policies which are no longer adequate and create new ones increasing efficacy of existing services." A consistent desire expressed among participants was for more veterans to be employed by the VA. A different interviewee suggested, "I would like to see a higher percent of veterans working as employees for the VA and for them to have more of a part in running the VA system, because they would better relate to veterans' circumstances." Ultimately, the veterans appeared to hold the beliefs that their comrades will better understand their plights.

Unfortunately, some of these desired changes may not be feasible because the issues lie so deep within the VA system, and, because of its top-heavy structure, adjustments of power hierarchies would need to be made. However, there were suggested solutions provided by participants that could be possible. As previously mentioned, the participant guide involved in the study is a veteran and has interned for the VA. He held some substantial experience with the VA system. He stated a few of his ideas for possible resolutions. For example, he indicated "The VA's suicide teams could be expanded by hiring more crisis workers." Further, he went on to say, "There needs to be improvement of directives governing PTSD, including a higher quality of counseling for veterans and their families." The reasoning behind this specific concept is related to the fact that veterans come home with a number of trauma-related issues. The effects of PTSD on returning veterans often results in serious impacts on veterans' families, including marital discord, domestic violence, and other negative consequences (Sayer et al., 2010).

Discussion

Improvements need to be made within the VA system; however, there are underlying issues that need to be addressed before solutions can be implemented. As one veteran stated, “The VA system is functioning to the best of its ability with the resources supplied by the U.S. government.” He also mentioned, “The U.S. military is one of the first government entities cut in times of economic recession.” Therefore, it is not surprising that the VA system suffers from those consequences as well. For the VA to increase quality of services, innovative movements must be processed through a hierarchical government system from Congress, descending to the VA. For changes to start taking place, U.S. citizens need to be educated about how these systems work and provide advocacy to support this population with obtaining essential services.

Education is the key to opening doors for improved knowledge about curing societal ills. Ideas for alleviation of such maladies may include private or non-profit social service agencies offering programs to educate the American public about challenges and barriers that veterans and their families face upon returning from active duty. One barrier includes the struggle to reenter the workforce. Veterans need to have access to resources enabling them to obtain vocational and educational training leading to successfully reaching their goals as a result. It was noted by Norman et al. (2015) that academic success reached among veterans was a result of having campus resources, such as student service centers offering tutoring, academic advisement, and mental health counseling.

The WSU campus offers such resources, and most of the participants involved in the study indicated that they were satisfied with services provided. WSU participants expressed concerns about attending the VA for treatment for fear that documents recording the services might get back to current employers, especially for veterans who were still currently enrolled in the military reserves. The fears seemed to be focused on the concept that if such employers knew the veterans were being affected by mental illness, there could be potential retaliation, such as loss of employment. Therefore, these fears of seeking treatment could inhibit success upon entering the civilian workforce again.

Mental health issues are another obstacle that veterans face upon deployment. In regard to resources for treating mental health, veterans interviewed during the WSU study stated they had fears about receiving such services because of social stigmas related to mental illness, especially those related to PTSD. Although both male and female veterans face similar issues upon deployment, as noted by Fox et al. (2015), male and female veterans perceive treatment of mental health

treatment from differing points of views, and female veterans are more likely to seek mental health services than men. Because there was only one female out of 10 veterans participating in the WSU study, it was more difficult to determine how females perceived treatment compared with males; however, the female participant stated, “Women who have returned home from active combat are more likely to seek services for trauma stemmed from sexual harassment and assault which took place during times of active duty.”

Senior veterans tend to have barriers while dealing with the VA after service for the rest of their lives. To support research findings by Hastings et al. (2013), it was noted during the WSU study that senior vets did indeed feel as though they were being left out on the ice, so to speak. As the one senior veteran indicated, VA emergency services tend to give opiates and send them on their way without treating underlying problems causing the pain. He stated, “They [VA] just throw pain medications at us and basically tell us we will be fine.”

Furthermore, federal, state, and local government entities could mandate that school systems include curriculum within social studies courses for the purpose of educating students, not just about the politics of warfare, but also the effects that it has on those who have been actively involved. An enlightenment of this caliber could alleviate the mistrust among veterans toward the VA and the general public, while also encouraging citizens to become more empathic and supportive of this population. If veterans had faith that the American public had their back, they might develop the courage needed to advocate for their own rights and privileges.

Future Directions

Although careful analysis of the data was performed, there are inherent limitations in terms of how far the data can be generalized. Since much of the data was collected in one small area of the U.S., opinions and perceptions of services are likely only to reflect local perceptions, and probably not perceptions of the VA throughout the country. Much of the data was also collected through interviews and generally corroborated through observations, but such data does not necessarily reflect reality as participant’s perceptions have likely been skewed by stories they’d heard from others in their community. Future studies would benefit from investigating the biases of the participants to see if negative views are more associated with veterans who hadn’t used the VA services yet, if negative views were based on hearsay, or if negative views result from unrealistic expectations of services from the VA.

Finally, it is worth noting the sample size of the study. Generally, qualitative studies have smaller sample sizes than quantitative studies, but a sample size greater than 10 would have been ideal for this study, especially considering the vastness of the VA system as well as the diversity of people represented in the armed forces. Participants in this study all also happened to be college students, which increases response bias because of non-college student veterans being left out of the study. Future studies could become more specific by looking at specific branches of the armed forces, focusing on specific subgroups of veterans (especially female veterans), and narrowing down parts of the VA system that receive better or worse reviews from veterans.

References

- Bagalman, E. (2014). The number of veterans that use VA health care services: A fact sheet. Congressional Research Service. Retrieved August, 28, 2017, from <https://pdfs.semanticscholar.org/ce24/d096dc90e1b5cae156fc738b7421de025d5a.pdf>
- Druzin, H. (2015). Vets report: VA care hard to get for mental health. Stars & Stripes. Retrieved November 11, 2015, from <http://www.stripes.com/vets-report-va-care-hard-to-get-for-mental-health-1.375600>
- Fox, A.B., Meyer, E.C., & Vogt, D. (2015). Attitudes about the VA health-care setting, mental illness, mental health treatment and their relationship with VA mental health service: Use among female and male OEF/OIF veterans. *Psychological Services*, 12(1), 49-58. doi: 10.1037/a003852
- Hastings, S.N., Oddone, Z.E., Olsen, M.K., Schmader, K.E., & Smith, V. (2013). Health services use of older veterans treated and released from veterans affairs medical center emergency departments. *Journal of the American Geriatrics Society*, 61(9), 1515-1521. doi: 10.1111/jgs.124171
- Hoge, C. W., Castro, C. A., Messer, S. C., McGurk, D., Cotting, D. I., & Koffman, R. L. (2004). Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care. *New England Journal of Medicine*, 351(1), 13-22. doi: 10.1056/NEJMoa040603

Mittal, D., Drummond, K.L., Blevins D., Curran, G., Corrigan, P., & Sullivan G. (2013). Stigma associated with PTSD: Perceptions of treatment seeking. *Psychiatric Rehabilitation Journal*, 36(2), 86-92. doi: 10.10367/h0094976

Morasco, B. J. & Dobscha, S. K., (2007). Prescription medication misuse and substance use disorder in VA primary care patients with chronic pain. *General Hospital Psychiatry*, 30(2), 93-99. doi: 10.1016/j.genhosppsych.2007.12.004

Norman, S.B., Rosen, J., Himmerich, S., Meyers, U. S., Davis, B. Browne, K. C., & Piland, N. (2015). Student veteran perceptions of facilitators and barriers to achieving academic goals. *Journal of Rehabilitation Research & Development*, 52(6), 701-712. doi: 10.1682/JRRD.2015.01.0013

Oliver, A. (2007). The Veterans Health Administration: An American success story. *Milbank Quarterly*, 85(1),5-35. doi: 10.1111/j.1468-0009.2007.00475.x

Sayer, N. A., Noorbaloochi, S., Frazier, P., Carlson, K., Gravely, A., & Murdoch, M. (2010). Reintegration problems and treatment interests among Iraq and Afghanistan combat veterans receiving VA medical care. *Psychiatric Services*,61(6), 589–597. <http://doi.org/10.1176/ps.2010.61.6.589>

Seal, K. H., Ying, S., Cohen, G., Cohen, B. E., Maguen, S., Krebs, E. E., & Neylan, T.C. (2012). Association of health disorders with prescription opioids and high-risk opioid use in US veterans of Iraq and Afghanistan. *Journal of American Medical Association*, 307(9), 940-947. doi: 10.1001/jama.2012.234

Yin, R. K. (2016). *Qualitative research from start to finish* (2nd ed.). New York: The Guilford Press.

Abstracts

ARTS

A case against the institutionalization of the full art process

Christopher Lynn

Brigham Young University

As art museums seek to reach new audiences and broaden the scope of their education departments, they not only exhibit work, but produce didactic texts, catalogs, timelines, panel discussions, and docent-led tours in an effort to contextualize the art on view. They also often venture into artist video interviews, documentary videos of the work being made and/or installed, studio visits, and artist and curator lectures. By institutionalizing and centralizing the creation, installation, contextualization, and audience conversation, a single academic narrative is created to portray simply what is often a complex and multi-layered artistic and cultural process. Art can be a difficult, challenging, wild creature. Museums may portray art and its processes as taxidermied artifacts—devoid of life and complexities. Hunted, captured, defanged, domesticated, categorized, and tagged, the art that is then placed on display acts as a shell or husk of what was and what could have been. This paper compares the display and treatment of artists' work in formal museums and artist-centered spaces. The performance artist William Pope.L's work is visceral, sometimes brutal, nuanced, and often tackles issues of race. His work, when displayed at institutions like MOCA in Los Angeles contrasts starkly with the presentation of his community-based project "Pull!" executed with SPACES, an artist-centered organization in Cleveland, OH. Rirkrit Tiravanija's exhibition "Free" (1992) at the 303 Gallery in New York City functioned as a distributor of free Thai food to visitors. When the work was recreated in 2011–12 at the Museum of Modern Art, not only was the context greatly changed to a full-scale, world-renowned museum, but it came with all the didactic trappings of a museum, thereby softening and sanitizing the experience.

ARTS

Arts in education: A means reforming failing schools

Kathleen Bunker Sheffield

Brigham Young University

The United States' educational system is currently facing challenges that include rising dropout rates, a narrowing curriculum, over standardized testing, a widening achievement gap, and an increasingly diverse student population. An education rich in the arts is the means by which we can begin to integrate greater learning, literacy, and cultural diversity. The learner should be at the center of our educational system. Knowledge comes from experience, not authority. The arts are rich in experience. Experience can change the brain's physical structure as well as its functional organization. Assessment-driven practices only consider improvement that is easily measured. The arts are marginalized under these practices. Creativity and the arts flourish when governed by democratic principles and are a necessary part of a nonhomogenized education. Dismissing the arts as a vital part of education limits the development of the full spectrum of human intelligence. The arts are instrumental in fortifying intrinsic benefits of an individual's identity, values, feelings, perceptions, opinions, and motivations. In an economic model, teaching and learning are driven by efficiency and rationalism. In an intellectual model, education is seen as an academic ability determined by memorization and the ability to learn by rote. These models assume that intelligence can and should be measured to determine progress. Interpersonal and creative processes are left by the wayside. New technologies of the future require new capacities and abilities. The arts have the potential to encompass and promote the intellectual, cognitive, humanistic, creative, socioemotional, sociocultural, and socioeconomic aspects of education.

ARTS

Intellectual theft or creative license? Copyright in the arts

Courtney Davis

Utah Valley University

Although the parameters and protections of intellectual property law have been debated for centuries, contemporary technology has

exacerbated the moral and ethical need to educate students about the rights and restrictions associated with the use of creative content. Our highly visual, content-saturated e-world has produced two alarming trends: first, the mistaken assumption that online content is different from and therefore not protected by the same copyright laws as tangible, printed material, and second, the “who will ever know?” or “catch me if you can” approach to content appropriation. While these attitudes may seem almost harmless in some situations, they threaten to erode the very foundation of copyright law, the purpose of which is to grant an original creator exclusive rights for use and distribution. This paper explores the ethical responsibility of teaching students of the visual arts about the importance of copyright protections and restrictions. This responsibility stems from the historical purpose of copyright, as well as contemporary applications and (mis)uses. Copyright ethics has been at the forefront of several recent high-profile appropriation cases, which have drawn the art community’s attention to the legal boundaries and moral implications of copyright protection. Because the legal domain does not provide a simple, bright line rule for fair use, the application of ethical principles is more vital than ever to the moral and responsible use of creative work. However, students of the arts often struggle with understanding the basic parameters of copyright law and because of this, the author proposes three moral duties with respect to arts education and intellectual

ARTS

The American narrative and *Fancy Free*

Tiffany Wyson

Weber State University

This research argues that there is an American narrative. Because of the genealogical diversity and abundance of immigration people argue whether there is a cultural narrative unique to the United States of America. Simone de Beauvoir and Jean Genet wrote about the distinctly laid-back behavior of the American soldiers swarming their Paris streets in 1944. Their observations of the unique American ways of moving, thinking, interacting, and behaving provide a lens on the American narrative. In addition to being laid-back and charismatic, Americans over time have been considered innovative, hard-working, optimistic, and independent. This narrative seems to be embedded in every aspect of the culture and is especially visible within cultural

artifacts, such as film, music, and dance. New historicism will be implemented in this research to provide a further understanding of the American narrative and life in the mid-20th century. This theory suggests that national identities emerge from and are shaped by the culture in which they reside. An analysis of cultural artifacts can provide deeper comprehension of cultural characteristics. Dance is a particularly revealing artifact in illuminating American customs, mannerisms, traditions, values, heritage, and aesthetics. The iconic American ballet, *Fancy Free*, choreographed by Jerome Robbins and premiered in 1944 in New York City, told the tale of three young American Navy sailors leaving for war. A review of written source material along with observation and examination of a video recording of *Fancy Free* and its symbolic “carefree” and “aimless” movement, through the principles of new historicism, will depict the typical American character that many like Simone de Beauvoir described.

BIOLOGICAL SCIENCES

The effect of acetaminophen on catalase activity in mouse liver

Emily James Esther Harkness, Laurie Mauger, Paul Pillitteri
Southern Utah University

Catalase, an enzyme found in high concentrations in hepatocytes, functions in the breakdown of reactive oxygen species. Reactive oxygen species (ROS) are the byproducts of oxidative metabolism and have been shown to cause damage to cells. In this study, mice were injected twice daily for two weeks with dosages of Tylenol, the active ingredient of which is acetaminophen. This ingredient has been shown to increase the production of ROS upon being metabolized. We hypothesized that regular dosage with the recommended amount of acetaminophen over a period of time would lead to decreased enzyme activity and beginning signs of liver damage. At the end of the injection period, the mice were humanely euthanized and their livers were dissected out and subjected to enzyme activity testing with hydrogen peroxide. Statistical analysis of the results showed a significant decrease in catalase activity after regular exposure to acetaminophen over two weeks. Our hope is that this study will contribute to the body of research concerning the regular use of acetaminophen.

BIOLOGICAL SCIENCES

A restriction site (in silico) reevaluation of a chloroplast gene phylogeny for a common fern group: Restriction site data can still provide new insights

William Speer

Salt Lake Community College

Although most molecular phylogenetic studies utilize nucleotide sequence data, other data sources still remain as important sources for the inference of evolutionary relationships. Several previous studies have evaluated phylogenetic relationships within the genus *Pteridium*, or bracken fern, using chloroplast rps4 gene and the rps4-trnS spacer sequence data. This study compares both sequence data previously submitted to Genbank with restriction site data (maps) generated in silico for rps4 and the rps4-trnS spacer. Phylogenetic analyses used *Paesia scaberula* as the outgroup taxon. Results of the restriction site analysis were mostly very similar to the DNA nucleotide results, though there were some differences. One of these is that the restriction site analysis suggested that *Pteridium aquilinum* subsp. *wightianum* (eastern Asia) has a much closer relationship with subspecies *pubescens* (western North America) and *decompositum* (Hawaii) than is suggested by the nucleotide sequence data. The restriction site data also joined the African *P. aquilinum* subspecies *capense* and *centrali-africanum* with North American, Hawaiian, and Asian representatives of *P. aquilinum*, but not with the European *P. aquilinum* subsp. *aquilinum*. Because this finding differs from previous phylogenetic analyses, it was very strongly evaluated in this study. Also examined in the nucleotide sequence data were indels found in the rps4-trnS spacer of *Paesia*, some of which corresponded to those previously reported for *Pteridium esculentum*, while another clearly distinguished *Paesia* from all *Pteridium* taxa. In addition to the phylogenetic analyses, the restriction site data generated for the *Paesia* and *Pteridium* specimens were further analyzed using principal components analysis (PCA) and non-metric multidimensional scaling (NMDS) ordination approaches. In the PCA and NMDS, *Paesia* was clearly distinguished from all *Pteridium* specimens. Three distinct *Pteridium* groupings were obtained in both ordination analyses: 1) *P. esculentum*/*P. arachnoideum*; 2) *P. aquilinum* subsp. *Aquilinum*; and 3) all other *P. aquilinum* subspecies (with two distinct subgroups).

BIOLOGICAL SCIENCES

Does the distribution of private dentists in Utah, USA match population need? A high-resolution GIS analysis

Emily Irwin, Brayden Mollner, and Sara Flood

Utah Valley University

Objective: The distribution of dentists in the United States is very uneven, and is determined by not only major population centers, but also by the distribution of different race groups and poverty levels. This study examined the interaction of dentist location and population demographics in Utah, by applying high-resolution Geographic Information Systems (GIS) tools to test the hypothesis that dentists are distributed relative to high population density and wealth. *Method:* Population data were obtained from the US Census Bureau (2010). The physical address for each dentist in Utah was collected and GIS tools were used to compare population demographics (census tract data) and dentist location. *Result:* The population of Utah was distributed across 588 census tracts. Of these tracts, 307 (52%) had at least one dentist. Of the most disadvantaged group, 45% had no dentist in their tract, while 32% of the more advantaged group had no dentist. A third of Native American Indians and Alaskans lived in tracts at least 20 km away from a dentist; however, the number for African Americans and Asians was 2%. *Conclusion:* It was found that dentists were unevenly distributed across Utah, with about half of census tracts having no dentist located within them. The more advantaged group of residents were more likely to be closer to a dentist. The number of Native American Indians and Alaskan people who lived at least 20 km from a dentist was over 20 times greater than that of African Americans and Asians.

BIOLOGICAL SCIENCES

Microbial analysis of art byproduct waste streams

Gabriel McKay, Michele Culumber, and Craig Oberg

Weber State University

Oil and acrylic art painting generates waste products related to solvents and paints used in the creative process. The initial phase of this research was aimed at finding and characterizing microorganisms from these art byproduct wastestreams. The goal is to find microorganisms

that could possibly speed up the process of biodegrading these materials, which are often resistant to breakdown. Samples were taken from the art waste collection cans in the art studios including what appeared to be biofilms on the storage containers, as well as sludge samples and individual solvents. Minimal media containing three separate solvents was inoculated with samples from the waste stream containers and incubated on a shaker for up to 4 weeks. Biofilms formed in some of the containers during prolonged incubation. Nine individual bacterial cultures were isolated, including 4 Gram-positive rods and Gram-negative rods and cocci. Taxonomic analysis of isolates shows a variety of bacterial species involved in degradation. Individual bacterial isolates have been incubated with varying concentrations of specific art solvents to determine their biodegradation capacity. We have found, isolated, and tested microorganisms that have the potential to biodegrade art waste while it is in the collection and storage containers.

BIOLOGICAL SCIENCES

Inhibition of *Lactobacillus wasatchensis* by bioprotective lactic acid bacteria cultures

Aaron Lavigne, Sam Smith, Craig Oberg, Isaac Bowen, and Don McMahon

Weber State University

The nonstarter lactic acid bacteria (NSLAB) *Lactobacillus wasatchensis* can cause late gassy defect when it grows to high numbers during Cheddar cheese storage. A potential strategy for preventing such growth is incorporation of specific lactic acid bacteria strains (termed bio-protective LAB) into the cheese during manufacture, which may specifically inhibit growth of *Lb. wasatchensis*. Determination of inhibition by common NSLAB lactobacilli and potential bio-protective LAB (BPLAB) strains against *Lb. wasatchensis* was done using the spot test along with the agar flip method. MRS agar supplemented with 1.5% ribose (MRS-R) was inoculated with each NSLAB or bio-protective LAB using the spread plate method and incubated anaerobically at 25°C for 48 or 72 h. Inoculated agar was then flipped over, and either *Lb. wasatchensis* WDC04 or CGL04 swabbed was on the newly exposed surface with anaerobic incubation at 25°C for up to 72 h. None of the BPLAB strains produced any more inhibition after 48 h than the general

competitive inhibition caused by the NSLAB cultures *Lactobacillus brevis* or *Lactobacillus fermentum* LF7469. When incubation time was extended to 72 h prior to challenge, BPLAB P200 showed the largest inhibition zones for both *Lb. wasatchensis* WDC04 and CGL04. The next inhibitory BPLAB was LB-3 with the NSLAB, *Lb. fermentum* LF7469, also producing a large inhibition zone. To test for bacteriocin production by the BPLAB, a paper disc assay test was performed using cell free extracts. Results confirmed a number of BPLAB strains produced a bacteriocin, showing a very small zone of inhibition for *Lb. wasatchensis* around the paper disc. Examining the antagonism between bio-protective cultures and NSLABs for *Lb. wasatchensis* strains allows for selection of lactic acid bacteria strains that could inhibit this problematic bacterium during cheese ripening.

BIOLOGICAL SCIENCES

Kava: An ethnobotanical monograph of *Piper methysticum*

Trevor Chamberlain and Olga Kopp

Utah Valley University

Historically found throughout most of the islands of the Pacific Ocean, *Piper methysticum* is a shrub cultivated for its rhizomes, which are used in traditional drinks or allopathic treatments. More commonly known as kava, *P. methysticum* has made its way into western cultures, typically administered as an anxiolytic, but occasionally used recreationally. The prominent effects of kava are caused mainly by compounds known as kavalactones found in the rhizomes of the plant. Recent studies have gone into discovering the pharmacology of kavalactone derivations and have found possible uses in the treatment of neurological disorders. Additionally, the biological activity of *P. methysticum* is believed to occur in the limbic structures of the brain as well as the endocannabinoid system. Current clinical studies have focused on liver toxicity, carcinogenicity, chemoprevention, and applications as an antidepressant. While many of the applications of kava are positive, contraindications include kava dermatopathy and liver toxicity. Additionally, a lack of quality control and standardization of commercial products is believed to be a possible cause of hepatotoxicity, leading some to believe more controls should be in place. This commercialization has led to the use of kava extracted into alcohol or acetone in capsules and sold as a natural product.

Furthermore, kava is consumed recreationally as a beverage, but the ceremonial context is often removed in attempts to attain a “legal high.” This research reviews *P. methysticum* and its uses highlighting the importance of additional research on kava’s activity and potential toxicity.

BIOLOGICAL SCIENCES

Taxonomy of *Penstemon leonardii* and *Penstemon platyphyllus* (Scrophulariaceae)

Stephen L. Clark

Weber State University

Penstemon leonardii and *Penstemon platyphyllus* (Scrophulariaceae) are morphologically very similar and have been difficult to separate using a taxonomic key. Observations by this writer suggested they may not be separate species, but rather represent an altitudinal cline with *P. platyphyllus* growing tall and robust at lower elevations and *P. leonardii* much smaller at higher elevations. Research supports the idea that these are good species and can be separated on morphological features. However, because they are sympatric through part of their range, a lingering question remained: “what is keeping these two species reproductively isolated?” Cytological studies of meiotic chromosomes provided an answer in that *P. leonardii* is a diploid while *P. platyphyllus* is a tetraploid. This paper examines the similarities and differences between these two taxa and suggests that *P. platyphyllus* originated as a consequence of *P. leonardii* doubling its chromosome number.

BIOLOGICAL SCIENCES

Characterization of lactic acid bacteria isolated from over-the-counter probiotic products

Rusty Crofts, Wyatt Powelson, Eric Lancaster, and Karen Nakaoka

Weber State University

Many studies have characterized laboratory strains of lactic acid bacteria (LABs), noting their potential health-promoting features that

has encouraged their use as probiotics. However, it is known that some LABs have traits, such as antibiotic resistance, that may have a negative impact on one's health. This study's purpose was to characterize 8 strains of LABs, all gram positive bacilli, that were isolated from 8 probiotic products, purchased without a prescription in Utah stores. The LABs were tested using the disk diffusion assay in which all 8 LABs exhibited antibiotic resistance to vancomycin, oxacillin, and bacitracin, while five were also resistant to cefoxitin and 3 were resistant to ciprofloxacin. The minimum inhibitory concentration of cefoxitin, oxacillin, and tetracycline toward the 8 LABs was determined using Etest strips. The results of the Etest and the disc diffusion assay were consistent when Mann Rogosa Sharp agar (MRS) was used for both assays. This was in contrast to Etest results that differed from the disc diffusion test results when, following the manufacturer's directions, sheep blood agar (SBA) and a higher concentration of the LABs was used instead. Interestingly, as a consequence of using SBA, five of the LABs were noted to be hemolytic after 48–72 hours of anaerobic incubation at 37°C. This is surprising since hemolysis is an indication of the potential for pathogenicity, yet probiotic LABs are generally considered harmless. This study is one of few that characterized probiotic strains obtained from products readily available to the consumer, indicating the potential for adverse outcomes from the use of these probiotics.

BIOLOGICAL SCIENCES

Selective primer development for rapid detection of the gas-producing non-starter bacterium *Lactobacillus wasatchensis*

Michele D. Culumber, Taylor Oberg, Tyler Allen, Fatih Ortakci, Craig J. Oberg, and Donald J. McMahon
Weber State University

Lactobacillus wasatchensis is a slow-growing non-starter lactic acid bacterium (NSLAB) that has been implicated in gas defects in aged Cheddar cheese. This organism has been detected in cheeses from seven cheese processing facilities in different regions of the United States, and is of significant concern to cheese producers. Rapid detection of *Lb. wasatchensis* would allow for better control of the organism and would help determine where it is entering the manufacturing process. A set of 16S rRNA primers was developed

using NCBI Primer-Blast against the *Lb. wasatchensis* genome and selected based on product length, melting temperature, and primer self-complementarity. In silico analysis against the NCBI database indicated that the primers should have high specificity for *Lb. wasatchensis*. PCR optimum conditions were determined experimentally with *Lb. casi* and *Lb. cuvatus* DNA as non-target template. To determine specificity, the primers were tested against DNA extracted from 22 different NSLAB strains, including strains of *Lb. wasatchensis* isolated from cheese and the original *Lb. wasatchensis* WDC04. Only strains identified previously as *Lb. wasatchensis* amplified with the primers. DNA from all isolates were amplified using standard bacterial 16S rRNA primers. The new primers, LW86Fa and LW258Ra, will be used in traditional and real-time PCR for the rapid detection of *Lb. wasatchensis* in gassy cheeses and the cheese-processing environment. Rapid molecular detection will help diagnose and track *Lb. wasatchensis* contamination and help control the occurrence of gassy-cheese defects.

BIOLOGICAL SCIENCES

Population dynamics of bat fleas in Great Basin Desert caves

Robert L. Bossard

Bossard Consulting

Cave ecosystems in the Great Basin Desert require conservation, especially with development such as wind farms. I model population dynamics of bat fleas and discuss factors regulating them. Bat fleas are significant fauna in many caves.

BIOLOGICAL SCIENCES

Development of assays to study inhibition of pathogens by lactic acid bacteria and their hemolytic ability

Brody Gibson, Cynthia Rudh, Christian Curneal, and Karen Nakaoka

Weber State University

Many have studied laboratory cultures of lactic acid bacteria (LABs), noting their potential to inhibit pathogens. One technique used for this

type of study requires that both the LABs and pathogens grow on the same agar plate. These studies often utilized Mann Rogosa Sharp (MRS) medium that favors the growth of LABs. However, when our lab attempted to replicate these studies, the pathogens struggled to grow on MRS medium, even without challenge by the LABs. In fact, when grown on MRS medium, *Staphylococcus aureus* exhibited faint growth at best and lost its ability to produce its yellow pigment. Thus, one purpose of this study was to determine which media would promote growth of the LABs obtained from over-the-counter (OTC) probiotics and six pathogens. Testing indicated that sheep blood agar (SBA) could grow both LABs and the pathogens. Using SBA in this assay allowed us to determine that all eight LABs inhibited *Streptococcus pyogenes* but none of the LABs inhibited the other five pathogens. It was also noted that the LABs grown on SBA induced hemolysis after 48–72 hours of anaerobic incubation at 37°C. This differed from the findings of others who did not see any hemolysis, likely because of limiting incubation to 24 hours. Further research is needed to determine if hemolysis is due to a hemolysin that targets red blood cells or if hemolysis resulted from the accumulation of acids elicited from the LABs. Another assay using SBA determined that hemolysis by some of the LABs was enhanced if the LABs were grown near *Escherichia coli* or *Shigella sonnei*. While others have studied laboratory cultures of LABs, this study is unique in its use of SBA to characterize pathogen inhibition by LABs obtained from OTC probiotic products and to study LAB™ ability to hemolyze SBA.

BIOLOGICAL SCIENCES

Identification and characterization of a new *Bacillus* species

Adriana Christensen, Donald Warner, and Jesus Soto

Dixie State University

A new *Bacillus* species isolated from human blood specimens was studied by phenotypic, chemotaxonomic, and genetic characterizations. This bacterium has phenotypic and chemotaxonomic characteristics similar with those of *Bacillus licheniformis*; however, 16S rRNA gene sequencing indicates the bacterium is a new species for which the name *Bacillus surgens* sp. nov. is proposed. This bacterium has adapted to exist in both the classic and L-form. Some antibiotics treat bacterial infections by affecting cell wall synthesis of the bacteria present, but

this novel bacterium does not have a cell wall in the L-form configuration. This adaptation has potential physiological benefits to the bacterium including, but not limited to, resistance to various antibiotics.

BIOLOGICAL SCIENCES

The effects of different proportions of acute exposure of ethinyl estradiol on giant danios zebrafish (*Devario aequipinnatus*)

A.J. Edwards and Samuel A. Wells

Southern Utah University

The presence and consequences of endocrine-disrupting chemicals (EDCs) have been of great concern in the past decade and a half in freshwater, estuarine, and marine environments. Detrimental effects of such chemicals have been shown in invertebrates, fishes, domestic animals, and humans. Accelerated growth rates, behavioral changes, hormonal interference, and altered mating behaviors have been documented in various species of fishes. We exposed giant danios zebrafish (*Devario aequipinnatus*) to four levels of the EDC 17 alpha estradiol to see if any behavioral effects could be identified in a laboratory setting. Fish exposed to the highest rates tended to congregate at the surface and gulped air more frequently than fishes exposed to lower levels of the toxin. Mortality increased at higher rates and a LC50 value was calculated.

BUSINESS

MDs or MBAs: Who is better at leading medical device companies?

David Benson, James Brau, and Derek Phelps

Brigham Young University

Individual physicians have become an increasingly important source of new medical device innovation. For example, the defibrillator, the stent, the pacemaker, the artificial hip, and the fetal heart monitor were all invented by individual physicians. More broadly, between 2000 and 2010, 20% of all patents in medical device technologies were invented

by physicians. This trend, in turn, has led many physicians to start new companies in order to develop and commercialize their inventions. Indeed, within the sub-segment of surgical device startups, 60% of the new startups had at least one founder who was a physician, and 22% were led by a physician CEO. Despite this increased contribution by physician inventors, scholars have devoted relatively little attention to examining it. Moreover, the research that has examined the role of physician inventors has largely focused on “interim outcomes” such as patents generated, rather than the ultimate measures that entrepreneurs and policymakers care about—new product approvals and startup success. In this paper, we seek to answer a simple question: Are startups managed by physicians more successful than those run by more traditional managers (the MBAs in our title)? We measure success in two ways: (1) Getting a new device approved by the FDA and (2) whether the startup is able to go public or be acquired. To answer this question, we examine all surgical device startups founded between 1985 and 2005 and then track their success through 2015. This paper is of interest to both academics and practitioners alike.

BUSINESS

Validating prior learning assessment utilizing a competency-based model

Jerry A. Van Os

Westminster College

Prior learning assessment (PLA) describes an assessment process in which students can earn college credit for college-level learning acquired outside a formal college curriculum. With PLA, students can progress more quickly towards degree completion, often at lower cost. PLA can be combined with a competency-based education curriculum to develop a “hybrid” approach that provides alternative pathways to degree completion for a significant population of non-traditional and transfer students with prior learning experience. To overcome concerns of academic rigor and quality associated with PLA, a uniform assessment process that measures student learning outcomes against per-determined criteria is critical. Direct assessment by full-time faculty of submitted artifacts that demonstrate mastery of associated competencies through prior learning experiences is an essential component of PLA. A process to validate prior learning through assessment with a competency-based model is described in this paper.

To validate the PLA process for a competency-based approach, a pilot study utilizing 24 students were selected to participate in a prior learning process. Pilot results indicated that overall, rubrics were sufficiently rigorous to assess program competencies associated with individual competencies. However, some rubrics were not sufficiently rigorous to assess program competencies and the paper provides recommendations to PLA assessment rubrics.

BUSINESS

Pay-per-click geotargeting advertising campaign

Conner Jasperson and Paige Gardiner

Utah Valley University

We are conducting this project to look at how to optimize costs on pay-per-click (PPC) campaigns for local companies using the Facebook Business Manager. Specifically the research will:

- Fine-tune interest marketing on PPC ads to suit the target market
- Conduct A/B tests with advertisements to determine successful fit for the business
- Apply geotargeting techniques
- Write copy and create digital imagery for posts

The research will also be presented to business and marketing students. With the new Digital Marketing Degree at UVU, many opportunities for students have opened. However, local marketing companies may not yet see the value that students offer holding this degree. Because Facebook algorithms are constantly changing, an empirical study is needed to learn and teach these new students. The research can also be used by many marketing professionals in small businesses who need an empirical case study to guide their decision making. Qualitative and quantitative case-study research that can be measured through the Facebook Business Manager. The research will be limited to a small business restaurant in Orem, Utah. Facebook ads with unique headlines, content, and calls-to-action will be created. High levels of reach and customer engagement for each ad will be analyzed in the collected data. There are several expected outcomes for the project:

- An expectation of 45% increase in Facebook page likes for the company

- Raise brand awareness as indicated by post shares, likes, and created stories
- What suggestions regarding client-customer relations can be made for those going into consulting:
 - Communication methods: Meeting times, email contact, phone calls, reporting findings, main person of contact
 - Client values, vision, and mission: Essential pieces to understand the client or company

BUSINESS

Chinese initial public offering roadshows and agreement between managers and investors

Jim Brau, Jim Cicon, and Shibo Bian

Brigham Young University

We study 782 initial public offering (IPO) roadshows for Chinese firms that went public between 2009 and 2012. Using transcripts of the roadshows, we employ Jieba, a Chinese Python word segmentation module, to conduct textual analysis. We do this because in the Chinese language, terms may compose both single words as well as multiword phrases. After segmenting the text using Jieba, we use the cosine similarity measure to compare investors' questions to management's answers. We define float rate as the number of shares issued divided by the number of shares subscribed and the turnover rate as the trading volume divided by the number of shares issued. Along with float rate and turnover rate, we examine how the agreement between investors and managers impacts IPO underpricing. Underpricing is defined as the percent change in the stock price between the IPO offering price and the first-day public closing price. We believe our study is the first to conduct textual analysis on IPO roadshow transcripts, as well as the first to do so in the setting of China. Our results indicate that agreement in the roadshow between investors and managers decreases the float rate and increases turnover rate (as defined above). We also provide strong empirical evidence that when the agreement between investors and managers during the roadshow is high, underpricing is also high. We show this effect after controlling for variables that the extant literature demonstrates significantly impact underpricing. We conclude with all three measures that when agreement is high during the

roadshow, demand is increased, as illustrated in all three dependent variables.

BUSINESS

A metastudy of microfinance academic scholarship from 2004 to 2016

Jim Brau and Mary Harrast

Brigham Young University

A significant amount of progress has occurred in the discipline of microfinance since the analysis of Brau and Woller (2004). In practice, Muhammad Yunus earned the Nobel Peace prize in 2006 along with the microfinance institution Grameen Bank that he founded, bringing international attention and validity for the process. Online funding platforms such as Kiva have introduced an entirely new dimension to funding microloans. In this study, we examine the academic microfinance literature since the Brau and Woller (2004) article. We analyze hundreds of articles and identify the progress, and challenges, encountered over the past nearly 15 years since the publication of that article. Key issues such as sustainability of microfunds, gender empowerment, poverty alleviation, funding mechanisms, adaptability to different countries and cultures, and the changing nature of microloans are all analyzed. We propose an agenda for future research in microfinance to advance both academic study as well as practitioner efficacy.

BUSINESS

A hedonic pricing analysis of the Utah Country single-family residential housing market

Jeremy Endicott, James C. Brau, and Barrett Slade

Brigham Young University

Homeowners and investors have differing views concerning where the residential housing market stands today. In this study, we examine the Utah County housing market using a sample of single-family residential transactions from recent quarters (data obtained from the Wasatch Front Regional Multiple Listing Service). To measure the

strength of the Utah County residential market, we examine the selling price, transaction volume, and the number of days the house is on the market. We compare housing prices using two models: a naïve model that simply calculates the average sell price over a period and a hedonic pricing model that gives a detailed, holistic view of how homes are priced. The hedonic model incorporates characteristics of homes not priced in the naïve model. Characteristics include total square feet above and below ground, age of house in years, garage space, total lot area, and many other factors. When using a hedonic pricing model, we find evidence that home values are increasing at a rate different than what the naïve model indicates, which may explain the disparity in homeowner and investor sentiment. Discrepancies of results from the two models are examined and compared and contrasted to those of Brau and Slade who conducted a similar study in 2001. This paper is of interest to both academics and practitioners alike.

BUSINESS

White collar crime: Attitudes and perceptions of Utah college students

Jill O. Jaspersen

Utah Valley University

Utah's Attorney General is heavily involved in prosecuting white collar crimes, and has a website dedicated to specific white collar crimes. Along with the Attorney General, Utah agencies feel an obligation to supply information to the public, including students, the uneducated, the aged, and any vulnerable population. One of the main protectors of these populations is the Utah Department of Commerce. The Department mission is to promote commerce and protect Utah consumers through fair commercial and professional practices. Under the Utah Department of Commerce, there are three active divisions which include the Utah Division of Securities, the Utah Division of Consumer Protection, and the Utah Division of Real Estate. The Buyer Beware List is maintained by the Division of Consumer Protection to protect consumers from individuals and businesses who have engaged in deceptive practices; supply consumers with pertinent information so as to aid them in their decision-making; and encourage the development of fair consumer sales practices. In 2013, the Division of Securities released a list produced by the North American Securities Administrators Association (NASAA), which included the Top

Investor Threats to investors and small businesses. The Division of Real Estate also has additional resources and public service videos. Depending on the crime, these five agencies and their websites will be helpful to first-time consumers as well as seasoned investors. In order to further future policy about white collar crime, it is important to survey what the attitudes of future consumers are regarding white collar crime. This will aid in forming good policy and education.

BUSINESS

The relationship between traditional and noninterest income at commercial banks

Richard Parsons and James Nguyen

Texas A&M University Texarkana

The relationship between net interest margin (NIM) and non-interest income (NII) at commercial banks has important implications for business strategy and regulatory policy. An additional fact motivating this study is that the literature continues to show conflicting results when analyzing the relationship between NIM and NII. This research will seek to resolve the conflicts in the literature by taking several important steps forward. *Improved Data:* This research will have data for a full 5 years after the financial crisis of 2008 and cover the years from 1992 through 2013. The scope of data used in this study is massive with over 140,000 records covering 28 financially liberalized countries. The data set now uses international accounting standards which are claimed to improve the integrity of bank data. *Improved Statistical Methods:* While the use of GMM was a large step forward using dynamic GMM takes the model to the next level through recognizing the importance of lags as well as endogeneity concerns so common with these types of models. This is the first time that dynamic GMM has been used to solve the simultaneous NII and NIM equations. *Improved Model:* The latest research on important variables is included resulting in improved calculations and consideration of new variables. Only theoretical variables are used from a microeconomic modeling perspective, however since some additional variables discussed in the literature review have received strong empirical support these will be included in our robustness checks. The model produces excellent statistical results, which support the hypothesized nature and depth of the debated relationship, allowing banks to set proper strategy and policy makers to align appropriate regulation.

BUSINESS

Equity issuance of health care firms after the 2007 market crash and the 2010 Affordable Care Act

Jim Brau and Troy Carpenter

Brigham Young University

We provide an empirical analysis of 195 initial public offerings (IPOs) and 547 seasoned equity offerings (SEOs) of health care firms which issued between 2008 and October 2016. This period represents eight years after the US financial crisis of late 2007 and also includes all equity issuances since the passage of the Affordable Care Act of late 2010. We compare and contrast our results with those of Brau and Holloway (2009) who study health care equity issuances from 1970 through 2008. We find that global health care issues in both the IPO and SEO markets are significantly over-represented in both the postcrash (2008–2010) and post-ACA years (2011–2016) vis-à-vis the overall equity markets. Consistent with prior studies, we show the existence of first-day underpricing in both IPOs and SEOs, along with poor long-run abnormal stock returns. We estimate cross-sectional multivariate regression models to explain the underpricing and long-run returns.

BUSINESS

A tsunami of need: Autism awareness in hiring and the workplace

Jonathan Westover, Teresa Cardon, Norman Wright, Ronald Miller, Kathryn Hughes, and Rebecca Garrido

Utah Valley University

This project is an ongoing initiative that aims to find what, if any, programs and training are being used by companies to better employ individuals with autism spectrum disorder (ASD). Utah has the third highest incidence of ASD in the country (1 in 58), with Utah County having the highest rate in Utah (1 in 40). There is said to be a “tsunami” of adults leaving the educational system heading into higher education and the work force. Organizations in our community need to critically analyze how they are currently addressing ASD in the workplace and how they will include this unique population in the

future. Individuals with ASD have many talents and skills they can bring to the work force (i.e., attention to detail, specialized focus in technology, programming, etc.), but thus far this group of individuals is grossly underemployed or unemployed. This project is an initial step in determining how to better support employers and employees who are looking to tap into the talents associated with ASD. There is minimal research on this topic and this line of inquiry will be beneficial to UVU, community partners, and business and autism communities nationwide. Furthermore, the community will benefit from this project in three strategic areas. First, we are exploring how companies can gain a competitive edge by incorporating individuals with ASD who bring a unique set of talents and skills into the workplace. Second, we are exploring what current health benefits exist to support families who may have children with ASD or employees who have ASD. Third, we are analyzing the legal issues or potential legal issues that can arise in the workplace with the American with Disabilities Act 504 Accommodation Plans. We hope to shine a light on these and other related issues to help

BUSINESS

Just-in-time inventory supply chain management in small manufacturing firms

Austin Nordblad, James C. Brau, and Kohler Callis

Brigham Young University

Brau, Fawcett, and Morgan (2007) demonstrate that supply chain management (SCM) practices add value to small firms as manifested in asset utilization, revenue generation, and competitive performance. They rely on survey results from 570 U.S. managers to draw these conclusions. We extend the work of Brau et al. (2007) by examining a specific segment of SCM, namely, just-in-time (JIT) inventory controls in accordance with the work of Mitra, Sundaram, and PS (2012). Our data sample comes from the Standard and Poor's Compustat database and provides a rich laboratory with thousands of firms and audited financial data. We begin our methods by providing summary statistics that go into great detail on the various segments of inventory control, such as raw goods, material in progress, and finished goods. We estimate regressions by four-digit SIC code to create industry-product-specific benchmarks for inventory levels and then compute the difference between the actual inventory held by small firms and the

regression-based benchmark. We use the variance on inventory as an independent variable and test to see how it correlates with the same three dependent variables of Brau et al. (2007) as well as stock returns over various horizons. Our study contributes to the lean manufacturing academic literature. Lean manufacturing is multi-dimensional and generally consists of management activities, JIT inventory management, supplier management, work teams, and quality systems. By focusing on just one of these segments of lean manufacturing, we are able to speak directly to the impact of realized JIT on a portfolio of performance measures.

BUSINESS

Fostering student engagement through understanding and internalizing the mission statement and values of extra-curricular organizations

Ryan Stephenson, Colt Rothlisberger, and Jon Westover

Utah Valley University

Many organizations around the world have used mission statements to help instill core values in their employees and volunteers to help them become invested and engaged as they work for the organization. For many college students, getting involved in extracurricular activities contributes to their success in developing their skills and gaining necessary experience for being competitive in the job market or being admitted into graduate programs following graduation. Even though many students across campus currently get involved in these extra-curricular activities, preliminary evidence suggests that many students' current level of engagement is not sufficient to drive the overall success of their extra-curricular programs or their individual benefits following graduation, due to their values having an improper alignment with the values of the organization. This paper will analyze Utah Valley University's Center for the Advancement of Leadership's (CAL) 2-year leadership development program called, The LEAD Program. We will examine to what extent a CAL student's understanding and internalization of the CAL mission statement influences their long-term engagement in the LEAD program. We will also analyze whether or not each student is fit for the program by measuring how the students' values align with the organizations' values. We hypothesize that the students who better understand the purpose of CAL and the LEAD program for themselves personally and for the organization as a whole

will be more engaged throughout their experience in the LEAD program. We also hypothesize that those students whose values are more fit for the organization will be more engaged and satisfied with their experience in the LEAD program. Online surveys will be administered to CAL students, with various questions exploring the relationship between LEAD students' engagement and their knowledge and internalization of the CAL mission statement.

BUSINESS

REIT SEO underpricing and prospectus strategic tone

Jim Brau and Troy Carpenter

Brigham Young University

Using a sample of 1,459 seasoned equity offerings (SEOS) by 223 real estate investment trusts (REITS) spanning from 1996 through 2015, we use content analysis to test whether the strategic tone of a company's offering prospectus (SEC Form S-1) has an effect on SEO underpricing. Using methods which are designed to sense either a negative or a positive strategic tone in the content of a document, we find that companies that use negative words in their S-1 filings negatively impact SEO underpricing. Surprisingly, in contrast to operating companies, REITS that use positive words do not have a commensurate positive effect on SEO underpricing.

BUSINESS

Is now the time to face the LIFO issue?

Jennifer Harrison, Dara Hoffa, Chelsea Dye

Westminster College

The U.S. Financial Accounting Standards Board (FASB) and the International Accounting Standards Board (IASB) worked during the early years of the 21st century in an effort to converge their separate accounting rules into one comprehensive, globally accepted set of accounting standards. Major issues were identified and some were addressed, resulting in several Accounting Standards Updates (ASU) for companies using U.S. generally accepted accounting standards (GAAP). Among the most recent and impactful changes were to Leases

and to Revenue Recognition. These two ASUs are likely some of the last, if not the last, of the issues identified early in the FASB/IASB convergence plan that resulted in U.S. GAAP changes. The flame of the FASB/IASB convergence has dimmed considerably. Currently, there is no convergence plan other than the continued improvement of financial statement information. Likewise, the Securities and Exchange Commission has backed down from recommendations that U.S. companies follow IASB standards. Given the current FASB/IASB relationship, continued convergence between FASB and IASB will be internally generated. From the perspective of the FASB, given the U.S. political environment (assuming business-friendly executive and legislative branches of the U.S. government), the next four years may be the most opportune period in which to make one additional, early-identified and yet unaddressed, accounting convergence issue. Identified early within the convergence process was the problem of the Last-In, First-Out (LIFO) inventory costing method. The issue being that the IASB accounting standards do not allow LIFO but U.S. accounting standards do. To complicate the issue, U.S. companies that use LIFO for tax purposes, must use it for financial statement purposes. We plan to review the current status of the use of LIFO within oil and gas companies, identifying any changes within recent years. Likewise, we plan to identify and review possible alternatives in bringing U.S. accounting standards closer to international standards.

BUSINESS

Budget habits of college students: An empirical analysis of expectations and realizations

John Talmage Brown and James C. Brau

Brigham Young University

Using three samples of over 800 college students from a large, private university, this study analyzes their spending expectations, realized habits, and dispersion between the two. First, we ask the students to project what they think their monthly budget will be throughout the semester. Next, we ask them to track their expenses for three months. Finally, we ask them to report their actual spending habits along with answering dozens of demographic and potential explanatory variables. We use univariate and multivariate econometric methods to explain the factors that determine 1) their expectations of future income and spending, 2) their actual income and spending, and 3) the difference

between the two. We extend the work of Hayhoe, Leach, Turner, Bruin, and Lawrence (2000), Henry, Weber, and Yarbrough (2001), and Libby and Lindsay (2010). Hayhoe et al. (2000) study spending habits of college students, but do so under the context of credit use. We study all spending, regardless if credit was used. Henry et al. (2001) administer a 13-item questionnaire and provide univariate descriptive statistics pertaining to budgeting practices. Our survey instrument has over 50 items and we are able to estimate multivariate models due to our large sample size. Libby and Lindsay (2010) explicitly study the budgeting practices of firms, whereas we extend this analysis to individuals.

EDUCATION

Entering Research for Social Justice 101: A critical and experiential STEM course for Latina/Latino undergraduates

Shireen Keyl

Utah State University

Disparities between Hispanic and White undergraduates in terms of STEM education are glaring: according to a national longitudinal study tracking the completion rates in the STEM fields among incoming freshmen, 33.7% of White students remained in STEM fields, while only 17.8% of Hispanic students did so. And, with the Hispanic population growing at an exponential rate and the fact that minority students are the “evanguard of America’s new racial and ethnic diversity,” it is imperative our country meet the academic needs of our Hispanic students; it is also urgent we as critical educators in higher education STEM fields provide equitable opportunities for all students. This presentation is based on a paper that introduces an innovative course piloted at an institution of higher education. This course, titled “Entering Research for Social Justice” combines the teaching of the scientific method with a culturally responsive curriculum and the utilization of critical pedagogy that focuses on social justice within the sciences in a workshop setting. The justification for such a course is supported by a Vygotskian theoretical framework, which emphasizes that a learner’s cognition is embedded in their social and cultural worlds. If we as educators connect a student’s learning to their heritage language and culture, we provide for more empowered learning. Students who enrolled in this course identified as Latina/o, Hispanic, or Mexican-American and spoke Spanish. All students were required to

apply for REUs (Research Experience for Undergraduates) and other national grants. Students were introduced to Latina/o STEM researchers on campus and were also required to apply for a research lab position. For the students who enrolled in our course, all of them received research grants and all of them found a research lab to work in the second semester.

EDUCATION

Pushing back: Meaningful evidence of teacher quality

Mary Sowder

Utah Valley University

As state and national scrutiny on teacher education has intensified, educator preparation programs (EPPs) are faced with the daunting task of providing evidence that their candidates are adequately prepared for effective classroom practice. Policy makers and accrediting agencies have started to rely heavily on linking teacher preparation programs to in-service teaching performance of their completers and then to K-12 student achievement in order to draw conclusions about the efficacy of EPPs. At the same time, some states and EPPs have chosen to use multiple and more nuanced measures for assessing program outcomes, including traditional observation instruments for classroom practices and professional dispositions, as well as standardized, performance-based measures of candidate learning, such as edTPA. The edTPA, a nationally available performance assessment for teacher candidates developed at the Stanford Center for Assessment, Learning, and Equity (SCALE), has sparked some heated discourse among teacher educators and teacher candidates. The proposed presentation will attempt to reorient the discussion to look at the potential for the use of edTPA as a formative measure used for program improvement, as well as one measure for the summative assessment of teacher candidate proficiency. The use of a standardized performance assessment for these purposes will be the focus of discussion and consideration within the broader issue of accountability for educator preparation programs. The story of one program's shift to considering program revision based less on faculty perceptions and biases and more on the collection and analysis of results including those from edTPA, will generate a discussion of the challenges in using a standardized performance assessment when attempting transformative change.

EDUCATION

Pre-service teachers' conceptions of differentiation in mathematics lessons: Theory and practice

Sue A. Womack

Utah Valley University

Transfer of learning into practice is difficult. We investigated preservice teachers' conceptions of differentiation of mathematics lessons, looking to see if 1) their conceptions of differentiation matched the theoretical model taught in class, 2) their practice as student teachers transferred the theory into practice, and 3) their practice as a student teacher differed from the practice they observed in their cooperating teachers practice. Preservice teachers observed and categorized cooperating teachers' use of differentiated instruction in mathematics lessons during an engaged learning field experience. They subsequently described their own math lessons as student teachers. Both quantitative and qualitative data were analyzed, giving a more complete picture of practice. The findings suggest that preservice teachers have an emerging conception of differentiation, that they use a narrow range of strategies, but that they report differentiating more often than their cooperating teachers.

EDUCATION

An empirical analysis of the determinants of college student major choice

Emily Johnson AND James C. Brau

Brigham Young University

The primary research objective of this study is to empirically examine what factors impact the decision of college students to choose the various majors of business. We examine the choice of accounting, finance, supply chain management, marketing, entrepreneurship, organizational behavior/human resources, strategy, non-business STEM, and non-business non-STEM. Using a sample of 512 students at a large, private university, we collect dozens of demographic data points to serve as independent factors. We then conduct univariate and multivariate econometric tests with the choice of major as the dependent variable. Our study extends the work of Al-Rfou ("Factors

that influence the choice of business major evidence from Jordan.” *Journal of Business and Management* 8.2 (2013): 104-8.) who examines the impact of variables that proxy for personal background factors and future job factors, along with other demographic control variables and how they relate with the choice of business major. Al-Rfou (2013) shows that the strongest personal correlates of major choice are parents, siblings, and friends. For future job factors, she provides evidence that prestige, money, and job opportunity are the most significant factors. We extend the work of Al-Rfou (2013) by using U.S. students (as opposed to students from Jordan), by including a more carefully constructed demographic control panel, and by including non-business majors. Our results provide a rich description of the factors that U.S. students consider when choosing their majors and allows us to compare U.S. and Jordanian students.

EDUCATION

Using community-engaged experiential learning pedagogy to engage Millennial students

Jonathan Westover

Utah Valley University

While much has been said (often negatively) about the Millennial student and worker, research has shown that as a group they are high-achieving, have a strong desire for ongoing personal and professional development, and tend to be seriously invested in making a marked sustainable impact on society and in the communities in which they live and work. So how do we better engage our Millennial students? One avenue is through the use of community-engaged experiential learning (or service-learning) pedagogy in the classroom and projects in the community. While service-learning is not a new phenomenon, this “civically engaged” experiential learning pedagogy has increased in popularity and usage in educational settings in recent years. Additionally, community-engaged experiential learning can be utilized to provide meaningful community service opportunities that simultaneously teach civic responsibility and encourage life-long civic engagement, while also providing opportunities for significant real-life, hands-on learning of important skills and vital social understanding for Millennial students. This research utilizes pre/post-test methodology to measure the skill development and attitudinal shifts in students engaging in community-based experiential learning projects, as well as

in-depth qualitative analysis of end-of-semester student reflections and community partner surveys.

EDUCATION

Instructional designer values as revealed through the use of inscriptions

Rebekah Inez Brau

Brigham Young University

The literature regarding inscriptions is rich with discovery, to include the reasons why designers sketch. However, there is little to no research regarding what sketching reveals about designers' values. Extant research has been done largely from an outside viewpoint. This outside view offers a fundamental definition of inscriptions, which is becoming more standardized in the academic education literature. Wardak (2016) introduces the term inscription as popular in the use of archeology and it is now just becoming common in instructional design. Inscriptions refer to any markings such as numbers, tables, diagrams, and charts; however, it is not limited to a specific form since inscriptions are used to capture abstract ideas. The literature on instructional designer values, however, is vague and requires a great deal of inference. For example, Wardak (2016) argues that inscriptions and visual materials created at any stage of a project may or may not contribute to later stages of design or further meetings. Two research questions that germinate from Wardak's (2016) work are: 1) Do designers place value on their initial brainstorming? and 2) Do designers discount their early processes and focus on the end design? Studying instructional designer's values is significant because if research is going to help instructional designers, scholars need to understand the designers' thought processes. Research cannot understand designers from a distance, which is the manner they have previously been studied. To gain answers to the questions from the point-of-view of the instructional designers, I conduct a series of three semi-structured interviews with six instructional designers. I use hermeneutic-ethnography, which is similar to open-discussion interviews with a few leading questions.

ENGINEERING

Simple strength of material experiment to evaluate the deflection of a beam

Jacob W. Carter and Ali Siahpush

Southern Utah University

In engineering applications, when different components such as beams, columns or foundations have been used, normally they are designed within the certain limits. Limits are placed on the amount of elastic beam deflection when it is subjected to a load. The design of such beams can be complex but is essentially intended to ensure that the beam can safely carry the required load. The purpose of this paper is to discuss the fundamentals of beam deflection and a simple and cost-effective method (integration method) to evaluate the amount of deflection and slope at the free end of beams based on the load. To test these fundamentals, a device was designed and built to evaluate the deflection in a beam. Upon successful completion of this exercise, participants will understand the concept of beam deflection and will be able to evaluate the deflection of a beam under different vertical loads. Our values obtained through experimentation and evaluated using beam theory match within 95% of the theoretical values.

ENGINEERING

A fundamental look at the unique properties of copper

Casey Cooper, Jacob Carter, and Justin Christensen

Southern Utah University

Copper has been used for centuries as a tool, religious symbol, and token of societal hierarchy. The use of copper has been mentioned in some of the oldest civilization records, even as early as 9000 BC in the middle east. Copper was the prominent element to bring civilization from the Stone Age into the Bronze Age. The physical, chemical, electrical, and magnetic properties have solidified its integral place in today's society. Its abundance, low extraction cost, and versatility make it an excellent material for a variety of applications. The following general properties will be discussed throughout this paper to give an expanded understanding of copper: physical, chemical, electrical, magnetic, optical, economic, and environmental. Mechanical and electrical properties of copper were experimentally evaluated and

compared to published values. Some of the more in-depth research areas include copper's resistivity, yield and tensile strength, modulus of elasticity, failure, annealing, and hardening. These areas have specific test data representing some of the distinguishing characteristics of copper, such as its ductility and electrical conductivity.

ENGINEERING

Encoding data on photographic media using OFDM

Fon Brown and Ethan Albretson

Weber State University

A spatial application of orthogonal frequency division multiplexing (OFDM) is explored that encodes and decodes digital data using photographic media. Photographic media typically lacks pixel density but provides superior color depth. Using grayscale images, the printing and scanning process was studied to characterize the transfer function of the overall transmission process. Data was then encoded into symbols with 8-PSK using 10 spatial frequencies in two dimensions. A cyclic border (the spatial equivalent to the cyclic prefix) was added to account for spatial transients. A means for synchronization and skew correction was embedded in the photograph to accurately identify the boundaries of each symbol. Images were rendered photographically, scanned back and decoded. The relationship between image size and bit error rate was then studied to determine the highest bit density that data can practically achieved using this approach. Preliminary results suggest that the bit density is comparable to QR code.

ENGINEERING

Effect of different potential combinations on characteristics of nanoparticles formed by dewetting

T. McKay Stoker and Nick Roberts

Utah State University

The interaction energy between a substrate and a film has great effect on the size and distribution of nanoparticles formed through dewetting (the contraction of a thin film into tiny droplets on a substrate). When the film is capped with another material, the interaction between the

film and the cap also affects size and distribution. To study these effects, a system with a silica (SiO_2) substrate and a thin film of gold (Au) is modeled in the Large-scale Atomic/Molecular Massively Parallel Simulator (LAMMPS). The interaction energy between substrate and film is changed between a chosen low, medium, and high value. A simulation is run with each of the three values where the gold is set to a high temperature (1400 K) and allowed to dewet. Pictures are extracted during each simulation and are used to determine nanoparticle size and distribution. An alumina capping layer is added to the system and simulations are run with all combinations of substrate and cap interaction energies (both alumina and silica have the low interaction with gold; alumina has the medium interaction energy, silica has the low interaction energy; both alumina and silica have the medium interaction energy; etc.). These simulations also produce pictures for size and distribution analysis. In total, 12 simulations are run and analyzed to study the effects of cap and substrate interactions on the characteristics of the gold nanoparticles formed.

ENGINEERING

Mesospheric altitude profile anomalies observed by SABER space instrument

Gene Ware, Brian Simons, and Doran Baker

Utah State University

The Earth has a natural airglow layer centered at about an 87-kilometer altitude. This airglow is the major source of natural brightness on a dark night. This emission layer is attributed to hydroxyl gas formed from the hydration of ozone. The typical layer shape is expected to be approximately Gaussian with a thickness of about seven kilometers; however, about thirty percent of the scan measurements observed from an artificial satellite have exhibited anomalous profiles. Multiple peaks and extended thickness are sometimes seen. This paper explores the likely causes of these anomalies.

**LETTERS—FOREIGN LANGUAGE, HUMANITIES,
PHILOSOPHY****Schwarze Vogelmenschen: The Tuskegee Airmen and
Charles Sumner Stone, Jr. through an interpretive
biography paradigm****Thomas C. Terry***Utah State University*

Time and selective national memory have burnished the culture surrounding World War II's "Greatest Generation," obscuring a brutal fact. While their manpower was essential to the war effort, African Americans were deeply conflicted and angry that the U.S. needed them overseas but denied them equality at home. The most visible examples of African American commitment to the war were the Tuskegee Airmen, legends for fighting the air war over Europe. But many Tuskegee Airmen were draftees and had no burning passion to fight and die for a racist country. Charles Stone was one of those African Americans draftees, transplanted abruptly from Connecticut to a far different world in Alabama. Sixty years later in an interview with the author he recalled, "I didn't feel any great patriotic fervor. Samuel Johnson said, 'Patriotism is the last refuge of scoundrels.' And I didn't want to be a scoundrel." He was delighted when the military shuttled him from training regime to training regime rather than into combat. The purpose of this study is to examine the struggles and consequences of the Tuskegee Airmen's experiences freed of nostalgia through Stone's career as exemplar. This study employs an interpretive biography framework differing from traditional approaches by "create(ing) literary, narrative accounts, and representations of lived experiences." The biographer is an integral rather than aloof component of the process, according to Norman Denzin, its principal exponent along with Jean Paul Sartre. After the war, Stone broke numerous color barriers as the first African American member of the White House press corps and of white Philadelphia newspapers. His career included two Pulitzer Prize nominations, the Congressional Gold Medal, the editorship of three prominent black newspapers, and prestigious professorships at two major universities. Stone was a Congressional aide and involved with the Civil Rights and Black Power movements.

**LETTERS—FOREIGN LANGUAGE, HUMANITIES,
PHILOSOPHY**

**Laying duck eggs: The Americanization of
Scandinavian immigrants in Utah**

Brian J. Simons and Doran Baker

Utah State University

During the second half of the nineteenth century, 30,000 Latter Day Saint (LDS) converts poured into Utah from Denmark, Sweden, Norway, and Iceland. Foreign converts to the LDS religion joined with the intent of emigrating to join church members in the United States. As the future emigrants joined the LDS faith by the thousands, they were pressed early on by LDS leaders to transition to Anglo-American LDS culture and tradition. This process was more difficult for foreign converts from outside the British Isles. Scandinavian immigrants elsewhere in America assimilated through a gradual, organic process, spanning several generations. In contrast, the Americanization of Scandinavians in Utah was rapid and severe, happening largely within the first generation, as the religion influenced all aspects of life, including gender roles, language acquisition, religious tradition, farming practices, and political gatherings. This essay discusses both the reasons behind the rapid assimilation of Scandinavian immigrants and the process itself.

**LETTERS—FOREIGN LANGUAGE, HUMANITIES,
PHILOSOPHY**

**Cracking the stained glass ceiling: Emmeline B. Wells
and her strategic arrangement patterns**

Tiffany Kinney

University of Utah

The intersection of faith and feminism is of interest to many rhetorical historians as female rhetors from these intellectual and religious heritages are frequently the subject of recent scholarship. These celebrated religious feminist voices span from 300 B.C. with Timycha, a woman involved in the sacred enclave of the Pythagoreans to women currently preaching in Protestantism. The women of The Church of Jesus Christ of Latter Day Saints, or the Mormons, exemplify one

important, but often neglected, site of female rhetorical power. Emmeline B. Wells (1828–1921) is of particular interest as a feminist rhetorician because of her revered memory as an authority in this community. For example, she was the longest running editor of the *The Woman's Exponent*, as she edited this periodical for 39 consecutive years and produced over 500 editions. But not only was she a prolific writer, she was also exceedingly persuasive, as she forged a position of legitimacy for Mormon women through her writings. This presentation relays the results of my analysis of Wells's writing in *The Woman's Exponent*, specifically examining her strategic and deliberate use of arrangement patterns. In her arrangement, Wells effectively “sandwiches” official church discourse, penned by the all-male Mormon leadership, in-between feminist discourse written by herself and national suffragists. Historically, this exposure from the practice of “sandwiching” is one step towards cultivating a greater position of legitimacy for Mormon women because its prominence gathers attention of a readership, who can effectively work for and support women's authority in this religious context. Ultimately, in this presentation and through my research, I create a fuller account of feminism within the religious context of Mormonism through the life of one Mormon feminist.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

Dissolving Harrop's semantic paradox concerning moral error theory

Melvin A. Davila Martinez

Utah Valley University

Moral error theory is the anti-realist meta-ethical position that all moral predications of objective value are false, for their truth-conditions fail to be satisfied by any truthmakers, since those truthmakers, i.e., objective value-entities or objective value-properties, do not exist. Hence, if P is a moral predication of objective value, e.g., X is [objectively] good, X is [objectively] wrong, or X is [objectively] permissible, etc., then moral error theory holds that P is false, making ~P true. Some, such as Harrop (“Semantic Paradox Concerning Error Theory.” *Aporia* 26, no. 1:13-26, 2016), charge that moral error theory, as initially formulated by J.L. Mackie, is self-contradictory, in the sense of it being logically inconsistent, for affirming Mackie's position

permits the derivation of a semantic paradox; Harrop's charge supposes that at least one negation $\sim P$ of at least one moral predication of objective value P is either itself a moral predication of objective value or entails a moral predication of objective value, thus permitting a proof in which both P and $\sim P$ are taken to be true. Harrop's argument hinges on a particular translation of $\sim P$. In this paper, I argue that while at least one translation of $\sim P$ may prima facie appear to be a moral predication of objective value, this is so only as a result of conversational implicature. Indeed, no translation of $\sim P$ is, strictly speaking, either itself a moral predication of objective value or entails a moral predication of objective value, and therefore Harrop's semantic paradox concerning moral error theory cannot be produced once this second-order position is embraced along with the following restriction to moral error theory: that it only applies to first-order positive atomic moral predications, rather than that it extends to the sort of negative existential predications Harrop relies upon.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

Out from the trees: Crusader rustics in *The Book of Contemplation*

Spencer C. Woolley
University of Utah

To paraphrase von Clausewitz, history is the continuation of philosophy by other means. One such confluence of thought and action occurred when the feudal denizens of the European peninsula decided that the end of the eleventh century would be an excellent time to undertake an armed pilgrimage to the Holy Sepulcher. If they met resistance on the way, well then, they wore chain mail and carried swords for that very purpose. They did encounter Byzantines and Turks, as well as a convenient, if not providential political vacuum that allowed them, after bloody deeds to assume suzerainty over a narrow strip of the Levant. Thus commenced almost two centuries of Crusader presence in the Middle East, a presence abhorred, then tolerated, then repulsed by the Islamic residents of the area. One such resident was the warrior-poet-scholar Usama ibn Munqidh, who composed the *Kitab al-tibar*, the *Book of Contemplation*. Usama dwelt in the middle of the twelfth century, when Crusader military power and Frankish political rule stood at its apex. Usama provides many reasons for his ill will

towards the Crusaders—their false religion, their persecution of Muslims, their unwanted and misguided rule of spaces that he regards as belonging to him, and those emirs to whom he owes allegiance. This paper examines a different paradigm in Usama’s critique of the Crusaders: their lack of urbanity. Of the many justifications for loathing the invaders of his homeland, Usama reserves his deepest ire for their lack of urban graces, their inability to function in civilized society, and their different view of honor; the Crusaders’ rustic roots provide a unique weakness for him to censure, and to justify greater Islamic action against them.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

English only vs bilingual education: The path to good health

Jorge Nitguritzer

Utah Valley University

When we talk about the personal progress we achieve when we speak more than one language, we generally think of the economic benefits that await us in the future. However, being bilingual has another side that is not often discussed but is just as important: the path to good health. An article entitled “Why bilinguals are smarter” published by *The New York Times* in March of 2012 shows the benefit of learning a second language. The author, Yudhijit Bhattacharjee, is an award-winning writer whose essays on science and medicine have appeared in prestigious newspapers and magazines such as *The New York Times* and *National Geographic* among others. “Speaking two languages rather than just one has obvious practical benefits in an increasingly globalized world. But in recent years, scientists have begun to show that the advantages of bilingualism are even more fundamental than being able to converse with a wider range of people. Being bilingual, it turns out, makes you smarter. It can have a profound effect on your brain, improving cognitive skills not related to language and even shielding against dementia in old age,” he says. In this paper, we will discuss how our health can benefit from learning another language. In addition, we will analyze how and why the state of Utah has become a pioneer in the United States in dual-language immersion programs.

**LETTERS—FOREIGN LANGUAGE, HUMANITIES,
PHILOSOPHY**

**The ethicality of the corporate goal to maximize
shareholder wealth**

Jim Brau and Hannah Brau

Brigham Young University

In an article that analyzes the ethicality of the shareholder wealth maximization (SWM) goal of the firm, Brau (2017) argues that under certain conditions, SWM is indeed ethical. Discussing SWM in the context of the ethics camps of deontology, utilitarianism, virtue ethics, and justice theory, she sets forth necessary and sufficient conditions for ethicality of the goal to maximize shareholder wealth. In contrast, Jones and Felps (2013) provide a utilitarian critique of the ethics of SWM and claim that it is not an appropriate goal of the firm because it does not optimally improve the social good. Hawley (1991) goes as far as to claim: “Overemphasis on the SWM objective by some companies can lead to dangerous or disastrous consequences for consumers, employees, or the general population.” In this article, we defend SWM by providing a utilitarian critique of the Jones and Felps (2013) and the Hawley (1991) articles. In contrast to Jones and Felps (2013), we use the platform of utilitarianism to argue that the SWM goal, in the proper setting, approximates optimality of social good more than any alternative goal. As part of our critique, we discuss the limitations of stakeholder theory (a leading alternative to SWM) and show why SWM is superior for promoting social and economic good.

**LETTERS—FOREIGN LANGUAGE, HUMANITIES,
PHILOSOPHY**

**Sex and politics: Gendered power structures in the
medieval romance tradition**

Audrey N. Saxton

Brigham Young University

In the Medieval Romance tradition, there are many poems that link the physical male body with established power systems. This link can be seen in poems such as “Havelok the Dane,” “Sir Isumbras,” and “Le Mort Darthur.” However, this ridged relationship between body and

politics only allows for narrow definitions of gender, power, and justice. If bodies try to deviate from these established definitions, violence is used to correct them and reestablish them firmly within the system. Additionally, in order for women to participate in this structure, they must violently alter their physical bodies to be more closely aligned with the male body. However, there are other poems in the Romance genre, such as “Sir Lanval,” “The Wife of Bath’s Tale,” and “Sir Gawain and the Green Knight,” that explore alternatives to this ridged structure through their depiction of female bodies. These hypersexualized and often bare bodies provide an antithesis to male-dominated power structures; in place of violence, the female embodied system allows for choice, ambiguity, and fluidity when faced with questions of power and justice. Through this survey of Romantic poetry, readers can see the tensions between the social institutions of the male-dominated society and the imagined female alternatives. The role that the physical body plays in systems of power and justice is not only important for understanding medieval societies, but can also help contemporary audiences recognize the importance of the physical body in policy making and justice systems.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

Politics in children’s literature: The case of Spanish novelist Belén Gopegui

Ana M. Aguilera

Utah Valley University

The idea of civic compromise has always been present in Belén Gopegui’s novels. She has defined her novels as experiments in which she presents values and behaviors radically opposed to those hegemonic in contemporary literature. From Gopegui’s perspective, most of contemporary literature focuses on personal problematics and, by doing so, it promotes among its readers political apathy as well as models of subjectivity characterized by individualism and fragmentation, making this literature an instrument for ideological hegemony by financial elites. Gopegui’s oeuvre aims to return politics into people’s lives by promoting the public dimension instead of the private and personal and, with that, she collaborates to create a new left-leaning vision of society and subjectivity. Her main goal is to promote a political project that aims for a radical form of democracy

and a form of capitalism tamed by political intervention. We will present how those literary and political projects appear in her books addressed to children: *El Día que Mama Perdió la Paciencia* (2009, *The Day that Mom Lost Her Patience*) on gender relations; *El Amigo que Surgió de un Viejo Ordenador* (2012, *The Friend Who Came Out from an Old Computer*) on unemployment, political activism and social media; and *El Balonazo* (2013, *The Ball*), focused on illegal immigration. Participants will become familiar with a model of left-leaning children's literature for the 21st century.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

Stopping the bleeding: Guatemala's national anthem '¡Guatemala feliz!'

Douglas C. Jensen

Utah Valley University

The original lyrics of the national anthem of Guatemala (made official in 1897), by the Cuban exile (and Honduran citizen, later nationalized Guatemalan), José Joaquín Palma, is full of the usual tropes present in most of the hymns of the American republics: slavery, tyranny, the constant threat of imperialist forces, and the great nobility of the people and its infinite desire to serve and defend the country. It is also a bloody hymn, since in the 12 stanzas (including "choruses"), seven of them present images of blood or use the word blood or bloody in some form. Another stanza makes mention of the stain on the flag, which certainly represents a reference to blood as well. Later, in light of sensitivities distanced from the reality of the struggle for Central American independence, in 1934 Professor José María Bonilla Ruano was asked to reform the lyrics to better reflect "harmony with our pacifist spirit." The revision by Bonilla Ruano brings a new perspective on the end of the hymn, which alludes to the images of the two symbols of the country, the flag and the quetzal. In addition to correcting the confusing description of the flag in the Palma version, Bonilla deftly brings the two symbols to the foreground by removing the abundant and inaccurate references to bloody violence, which are in fact practically nonexistent in the country's struggle for independence from Spain. The present work considers the function of the anthem as a tool for simultaneous evaluation of both the historical past and the idealized

future of Guatemala, as envisioned both before and after the Bonilla Ruano revisions.

LETTERS—LANGUAGE AND LITERATURE

Radical innocence: Romanticism, Whitman, and the transcendent power of love

John Schwiebert

Weber State University

W.B. Yeats described a cognitive state beyond original innocence and critical awareness as “radical innocence,” in which adult awareness is sustained and even deepened while being at the same time transposed, from a minor to a major key, by love. It is within this transcendent condition of radical innocence that certain poets live. Using Walt Whitman as a case example, this paper demonstrates how radical innocence is concisely articulated in two particular poems: first, in the familiar “What is the grass?” section of “Song of Myself”; and second, in the 1855 autobiographical poem, “There was a child went forth.” These poems illustrate the process by which wordly experience and knowledge, both bitter and sweet, are transmuted into joy through the transformative power of love and can assist us in our own quests for life-affirmation in the face of doubt, difficulty, and negation.

LETTERS—LANGUAGE AND LITERATURE

Fractal theory and London chaos in *A Study in Scarlet* as keys to understanding Holmes’s genius

Holly Boud

Brigham Young University

In Sir Arthur Conan Doyle’s *A Study in Scarlet*, the world met for the first time the high-functioning sociopath and cultural icon, Sherlock Holmes. While fans have long questioned the source of his appeal and genius, thoughtfully considering such elements as his partnership with Watson or his manner of investigating crimes, no one has adequately assessed Holmes’s relationship with London. I assert that we cannot understand Holmes if we don’t understand London and that it is Holmes’s ability to interpret the seemingly chaotic networks of

nineteenth-century London that is the heart of his appeal. I apply the organizing principles of fractal theory to Holmes's relationship with London, showing that he never acts randomly but strictly within a law of order as he reads patterns of creation and representation underlying apparent chaos, intuitively deciphering variations among repeated patterns to create order from disorder, systemization from chaos.

LETTERS—LANGUAGE AND LITERATURE

Needing more than “Room”: Virginia Woolf and the equality of difference

Elizabeth DeBetta

Utah Valley University

In two of her best-known works, “A Room of One’s Own” and “Three Guineas,” early twentieth-century feminist Virginia Woolf details the plight of women of her era while also asserting potential roles enabling women’s social, political, and literary success. Woolf’s stylistic and rhetorical strategies align her with fourth-wave feminism in ways that afford her century-old argument continuing relevance to today’s creative, educated women. Through a conversation beginning in “A Room of One’s Own” and expanded in “Three Guineas,” Woolf advocates forward-thinking, visionary use of existing power structures to achieve what might be called an “equality of difference”—an equality that embraces, celebrates, and depends upon gendered differences.

LETTERS—LANGUAGE AND LITERATURE

The Dickens Curse; or, Charles Dickens’s 1842 visit to Cairo, Illinois

Todd Goddard

Utah Valley University

Charles Dickens’s visit to Cairo, Illinois, in 1842 was both typical and unusual. Given its location at the juncture of America’s two great rivers, it was typical for those traveling along the Ohio River to the western territories to pass Cairo. What makes Dickens’s visit unusual is his caustic description of Cairo—arguably the most scathing in his

American Notes. He would later fictionalize it as the dreadful “Eden” to which Martin Chuzzlewit is drawn from England to America in pursuit of a vaunted land deal. But what *American Notes* and Martin Chuzzlewit both seem to register is an acute anxiety over land and a foreboding sense of “placelessness.” *American Notes* records a society in the midst of an industrial revolution—and thus one marked by transience, instability, circulation, and homogenization. In contrast to England, at least for Dickens, America was a land without roots. Indeed, *American Notes* critiques the unsettled and mobile dynamic that Michael Chevalier referred to in the 1830s as “the ever-moving sea of speculation” where all is in “circulation, motion, and boiling agitation.” As with Chevalier, Dickens found that no “place” was sacred in America; no place was built to last; no place was free from the signs of the fleeting and the temporary and the flux and flows of capital tethered to America’s “speculating spirit.” And no locale exemplified these phenomena more than the unlikely Cairo, Illinois.

LETTERS—LANGUAGE AND LITERATURE

Shiva dances on: Rediscovering the novels of L. H. Myers

Sean Jenkins

Weber State University

Leopold Hamilton Myers (1881-1944) was son to a famous father: F. W. Myers, a classical scholar and founder of the (still extant) British Society of Psychical Research. Abandoning his father’s spiritualism in middle age, L. H. Myers found his own voice as a poet and novelist of ideas. Three of his novels, initially published in the first quarter of the last century, have recently been republished together as *The Root and the Flower*. Based on the India of Akbar the Great, the novels are at the nexus of two competing interests: an anachronistic Victorian imperialism toward the India of the real world and an India of the imagination, a place in which to stage a philosophical drama free of the binary of conqueror and conquered. Situated in a cauldron of competing religious claims, the novels rehearse arguments in a violence-free world for the best realization of the old dictum: know thyself. Myers examines the question of self-knowledge in context of another: what is the real? In an imaginary India, free of the risk of bloodshed, characters in the novels make competing claims for life’s ultimate purpose. Some choose the sensualist path of the Vamachari,

dissolving in the pleasures of the flesh; others argue for the self-renouncing path of the Buddha. Evoking comparison with the novels of Vardis Fisher, Myers examines life choices against a static political background, putting the choices themselves in stark relief against backdrops of enduring paradigms of ethics and beauty.

LETTERS—LANGUAGE AND LITERATURE

Shattered: How loss and grief become relational terrorism in Mahajan's *The Association of Small Bombs*

Malori Crossley

Weber State University

Karan Mahajan's 2016 novel, *The Association of Small Bombs*, explores the profound aftereffects of a small bomb blast on two families. Focusing on breakdowns in intimate relationships—where those who should be most intimate shut one another out from their shared grief—Mahajan considers how deliberate miscommunication turns grief and loss into weapons. I define deliberate miscommunication as the withholding of whole, true thoughts from an intimate other while fixating on a single (and often self-centered) aspect of an issue. A kind of emotional blackmail, withheld information is a source of power and leverage to the withholder and invariably leads to relational terrorism—which, in turn, is the leveraging of deliberate miscommunication to shame, blame, or pressure the intimate other into meeting the expectations or demands of the withholder. In Mahajan's novel, Vikas and Deepa Khurana ostensibly use deliberate miscommunication to work through the grief process—but in reality to assign blame to the other and thereby justify their own thoughts or actions. Using psychology theory explaining shame and couple violence, I will examine the origins, mechanisms, and consequences of the characters' relational terrorism.

PHYSICAL SCIENCES

Migration of lipids in a supported lipid bilayer

Douglas Hutchinson

Southern Utah University

Membranes and membrane proteins have a profound influence on life. These influences are important to consider in scientific fields such as biology and medicinal chemistry. However, these can be hard to study unless we can successfully isolate each of the membrane components. In our research, we are simulating lipid and membrane protein motion under a technique called electrophoretic/electroosmotic focusing (EEF) by use of a computer program in attempt to improve the technique. EEF has been shown to separate lipids and proteins, but the behavior of these lipids and proteins is not well understood in all phases of the separation. Our computer simulation will allow us to model the behavior of neutral and charged lipids and proteins in all stages of the separation. Our simulation calculates the movement of charged lipids. We are currently able to simulate the motion of two different species of charged protein and lipids. By optimizing our simulation using experimental data, we hope to reduce lipid migration to a one-dimensional simulation that will be time and cost effective. This will help to increase understanding of protein/lipid interactions and functions for many important purposes in the science fields.

PHYSICAL SCIENCES

Optimization of broadband multilayer mirrors via a genetic algorithm

Michael Greenburg and Steven Turley

Brigham Young University

The utility of space observatories is limited by their range of collectible wavelengths; it is therefore ideal to maximize this range. I will report on the results of designing and optimizing multilayer mirrors for broadband reflectivity, especially in the vacuum ultraviolet. Because of the immense number of possible layer combinations and thicknesses for a multilayer mirror, I automated the mirror selection process. A genetic algorithm selects and mutates the best portion of a given population of objects that fit given design criteria to create a new population. Starting with a random population, the process is iterated as many times as

desired, in the end yielding a high-broadband reflectance mirror that is then optimized via gradient search. I found that placing a few layers under a very thin aluminum coating significantly increased EUV reflectivity, which would give access to important spectral lines such as that of the dominant He-II transition.

PHYSICAL SCIENCES

Effects of roughness on reflection of monochromatic light

Spencer Thevenin and Steve Turley

Brigham Young University

If the scale of the surface roughness is on the order of the wavelength of incident light, traditional optics methods like ray tracing and physical optics fail to adequately model reflectance. In this project, boundary integral techniques were chosen because they provide direct solutions only limited by computer memory. Discretizing Maxwell's equations across a surface yields an $Ax=b$ matrix equation relating the surface current to electric field over a net of points. Reflectance calculations for transverse-magnetic (TM) waves on a perfect conductor in two dimensions are analyzed in depth to model the effects of scattering from surface roughness. Surface roughness more than a hundredth of the wavelength of the incident beam is noticeable, and anything larger than a tenth of the wavelength dominates the reflectance calculation. The effects of spatial frequencies are also analyzed. These calculations allow for comparison with previous approaches—such as the scalar correction factors of Debye-Waller—at various spatial frequencies.

PHYSICAL SCIENCES

Smoothed particle hydrodynamics modeling of double white dwarf mergers

Brandon Wiggins, Jan Staff, and Wesley Even

Southern Utah University

R Coronae Borealis stars are yellow supergiant variable stars with a hydrogen-deficient spectrum. A proposed means of producing R

Coronae Borealis stars is the merger of two white dwarfs with minimal dredge-up of O16 from the accreting star because observations of these stars put the O16 to O18 ratio close to unity. In this paper, we summarize our recent efforts to model the merging of a series of white dwarf pairs with a small variety of mass ratios and helium/oxygen abundances with a parallel smoothed particle hydrodynamics code SNSPH. We present comparisons to similar calculations carried out in Eulerian codes, finding that SPH predicts much less mixing between accretor and donor particularly if the accretor possesses a small layer of He on top of CO white dwarf.

PHYSICAL SCIENCES

Evaluation of the stereochemical selectivity of the nucleophilic addition reaction of the menthylmagnesium chloride grignard reagent with phenylisocyanate

Myla R. Pereira, Rebecca L. Maedgen, and Nathan S. Werner
Southern Utah University

Menthol is a natural product isolated from mint leaves and is the active ingredient found in cough drops. It is a six-membered carbon ring that contains three substituents: an alcohol, isopropyl, and methyl group. Six-membered rings exist primarily as an equilibrium mixture of two chair conformations that minimize angle and torsional strain. These conformations for menthol are not degenerate and thus can affect the reactivity of the functional groups contained on the ring. The focus of this research project is the evaluation of the stereochemical selectivity that results from a nucleophilic and stereochemically labile carbon-magnesium bond contained on a menthol-derived six-membered ring. For example, the reaction of (1R,2S,5R)-menthylmagnesium chloride and phenylisocyanate at 0°C produces the addition product in 69% yield. No isomeric products are observed by analysis of the crude reaction mixture by gas chromatography coupled mass spectrometry. Coupling constant analysis of the product suggest that the (1R,2S,5R) diastereomer is the major product of the reaction. The potential applications of this research could be in the production of chiral menthol-derived catalysts for the production of new enantioenriched medicines.

PHYSICAL SCIENCES

Smoothed particle hydrodynamics simulations of proto-planetary collisions in the early solar system

Morgan Taylor and Brandon Wiggins

Southern Utah University

The abundance of carbon and other volatile elements in Earth's mantle and biosphere is too unusual for self-development, because of the iron-rich core's affinity for these elements; we would expect to find carbon trapped within the core or else evaporated out of the atmosphere. This has motivated the hypothesis that Earth has accreted the volatile elements over its 4.4-billion-year lifetime. Recent studies discourage that the cause of this phenomenon came from meteorites and asteroids, as the ratio of silicon and carbon in these objects don't match up with the abundances of carbon and silicon within Earth's mantle. However, a collision with a mercury-like body, which had a silicon-sulfur rich core, may explain the paradox. While this idea promotes the possible cause of the carbon-rich mantle, no detailed hydrodynamic calculations exist. To successfully merge the planetesimals, the cores must unite as well as the mantles. In this paper, we use a parallel smoothed particle hydrodynamics code to analyze impact parameter vs. collision speed to better understand what conditions were necessary to produce the resulting volatile elements in the mantle.

PHYSICAL SCIENCES

Preventing oxidation in aluminum for EUV-reflectance with cadmium and zinc

Stephanie Thomas

Brigham Young University

Pure aluminum mirrors optimize the reflectance of broadband mirrors for space-based telescopes; however, they oxidize instantly in atmospheric conditions, decreasing reflectance in the far-UV from 90% to 20%. I apply the largely untried method of Removable Volatile Aluminum Protection (REVAP) by overcoating freshly deposited aluminum mirrors with a barrier layer of cadmium or zinc intended for removal in vacuum. I use ellipsometry and energy dispersive x-ray spectroscopy (EDS) periodically to observe how the barrier layers

interact with the aluminum and how the composition of the mirrors changes with time. Preliminary EDS results show zinc has possibly prevented aluminum oxidation in samples. Cadmium and zinc exhibit low adhesion to aluminum, making REVAP with them unfavorable.

PHYSICAL SCIENCES

Waste and cost reduction by reprocessing used motor oil into a synthetic diesel fuel

J. Kevin Shurtleff, Kyle Sweetman, Austin Beatridge, and Ryan Bernal

Utah Valley University

Utah Valley University has an abundance of waste motor oil (WMO) from the airplanes, motor vehicles, and utility vehicles operated by the University. Currently, there is no well-documented procedure for reprocessing the WMO into a useful fuel without expensive industrial equipment. The primary goal of this project, led by Professor Kevin Shurtleff and performed by undergraduate research students, is to repurpose the WMO into a useful, synthetic diesel fuel with a cost-effective, scalable process we've developed. Diesel fuel is a mixture of hydrocarbons. Motor oil (a heavier hydrocarbon) can be diluted with a lighter hydrocarbon, such as unleaded gasoline, to produce a synthetic diesel fuel that has comparable molecular weight and chemical properties to diesel. The two main obstacles in the reprocessing of the WMO is getting the oil clean enough for re-use and determining the optimum ratio of motor oil to the other lighter hydrocarbons in the fuel mixture. We have tested multiple ways to remove impurities. However, double centrifugation is the most cost-effective and efficient method. We have prepared various mixture ratios (mol%, wt%, and vol%) of WMO and unleaded gasoline to produce an efficient synthetic diesel fuel. The goal is to produce a diesel fuel replacement for use in the utility vehicles on campus. This means that every gallon of repurposed WMO eliminates disposal costs of the WMO and saves the University the cost of a gallon of diesel fuel. In this paper, we will describe the equipment, processes, and results achieved on the project, including test results for various WMO mixtures run in a diesel powered generator.

PHYSICAL SCIENCES

Development of a low-cost PDMS modular microfluidic device for STR analysis of genomic DNA

Sharla Winn, Chris Monson, and Jackie Grant

Southern Utah University

Microfluidic devices, or micro total analysis systems (μ TAS), achieve the same results as conventional assays in a fraction of the time and at considerably reduced cost. We are developing a low-cost, simple-to-operate, and portable μ TAS for short tandem repeat profiling that would be a step toward timely and efficient processing of forensic evidence. Our device is made from PDMS, an inexpensive silicone elastomer, using a sacrificial magnesium wire to form the reaction chambers and flow channels, thus eliminating the need for expensive materials and fabrication equipment. Our design takes advantage of PDMS chemistry and the adsorption of DNA to its surface components. We alter the roughness and surface chemistry of the reaction chamber by scratching the magnesium wire before fabrication and chemical treatments prior to protein or DNA adsorption. For initial experiments, plain, scratched (cross-hatched), and sanded magnesium wires were used to form reaction chambers in PDMS. Protein and DNA adsorption to chambers with varying surface roughness is currently being investigated by measuring retained fluorescence after incubation of Texas red-labeled bovine serum albumin or pico green-labeled DNA. Future work will involve PCR amplification on a PCR thermal cycling block. On-chip thermal cycling, sample addition, and cell lysis will be developed at a later stage of the project.

PHYSICAL SCIENCES

New 4-polytopes found by closest packing of spheres and tessellation in 4-D space

Chin-yah Yeh

Salt Lake Community College

The closest packing of 4-balls is used to find a new class of uniform 4-polytopes, besides the 64 convex 4-polytopes listed in the literature. Structures of these 4-polytopes are explained and orthographic

projections presented. Possibility of tessellation of these 4-polytopes in 4-D space are discussed.

PHYSICAL SCIENCES

Synthesis and characterization of lead- and tin-based solar cells

Heather Browning, Andrew Sandoval, Nick Allen, and Meagan Parker

Weber State University

Because of growing concerns of the changing climate, focus has been placed on alternative energy sources including new forms of solar cell materials that are inexpensive and environmentally friendly. Perovskite-based solar materials are a promising replacement for traditional silicon-based cells and supply the important features that are demanded of the next generation of solar energy. In this presentation, we will discuss our efforts at Weber State University to make lead- and tin-based perovskite solar cell materials.

PHYSICAL SCIENCES

How optical spacer layers could help in obtaining optical constants of highly absorbing materials in the extreme ultraviolet

David Allred, R. Steven Turley, Stephanie Thomas, Alexandra V. Davis, and Margaret Miles

Brigham Young University

The presence of interference fringes in thin-film reflectance and transmission are invaluable in obtaining optical constants from materials. When a material is highly absorbing however, interference fringes may not be visible. Hilfiker et al. (Hilfiker, James N.; Singh, Neha; Tiwald, Tom; et al. Survey of methods to characterize thin absorbing films with spectroscopic ellipsometry. *Thin Solid Films* 516(220): 7979-7989, 2008) have explored the problem of obtaining optical constants in the UV, visible and IR from highly absorbing materials using spectroscopic, multiangle ellipsometry. One particularly noteworthy technique is to place a transparent layer

beneath a semitransparent metal thin-film. Light passing through the film reflecting off from the substrate and then transmitting again through the film interferes with the front surface reflected light producing interference fringes as a function of wavelength or angle that highly constrain the optical constants. We will discuss the extension of such a technique into the extreme ultraviolet, showing how it solves important problems. Aluminum looks particularly promising as a spacer layer.

PHYSICAL SCIENCES

China's environmental resettlement: controversy and complexity

Megan Raines

Utah Valley University

In spite of being the fourth largest country in the world, population distribution is one of China's primary concerns. Regions that are too dry or mountainous to be suitable for farming, industry, or daily human activity comprise large portions of its landmass, so more inhabitable areas face overcrowding—taxing water resources and raising pollution to dangerous levels in most cities. The large Gobi desert has continued to expand, causing China to become increasingly conscientious about global warming and the need to mitigate its effects. Resettlement programs respond to environmental concerns, as well as the need to support rural villagers who live in poverty resulting from dwindling resources, but mandatory resettlement is controversial. Recently, journalists have given a voice to many who, after generations of work on family lands, or in established careers, feel they have been forced into abandoning life in their rural communities. While China should be lauded for increased attention to global warming, inefficiency and corruption still thwart environmental protection efforts, making human resettlement seem trivial compared to other measures that are neglected in the interest of industry. This paper will examine these and conflicting reports and explore the possibility that environmental resettlement places undue burden on minorities, without demanding change—through increased censure and incentivizing—from industries whose practices contribute more to warming trends and soil erosion than mountain and desert inhabitants.

PHYSICAL SCIENCES

Renewable energy insights through hydrogen sulfide oxidation

Matthew Wilkinson, Justin Talbot, J.D. Herr, Sarah Floris, and Ryan Steele

University of Utah

Renewable energy insights through hydrogen sulfide oxidation promising renewable energy sources are derived from the conversion of sunlight and water (H_2O) into chemical fuels, but robust catalysts to make this process efficient remain a scientific challenge. Known biological processes perform similar redox chemistry of hydrogen sulfide (H_2S), and the aim of this work is to investigate the mechanisms of H_2S oxidation for the purpose of providing new insight into solar fuel generation. Computational chemistry simulations have been used to 1) predict the structural trends and thermodynamic driving forces of gas-phase H_2S clusters upon ionization, 2) determine the real-time molecular dynamics of these ionization processes, and 3) compute infrared absorption spectra of key species in order to verify these computational results and connect to experimental studies. The behavior of $[\text{H}_2\text{S}]_n$ from $n=1-21$ clusters is very unique in comparison to its H_2O equivalents. One difference is in the stabilization of the radical electron; Hydrogen sulfide stabilizes its radical electron in a hemi-bond manner compared to the proton-transfer like fashion of $[\text{H}_2\text{O}]_n$ clusters.

POSTER

The effect of hydrogen peroxide on *Artemia*

Jerome Austin Johnson and Nicole Berthelemy

Weber State University

The brine shrimp *Artemia* inhabit the Great Salt Lake, a harsh environment where stresses, including oxidative stress, are common. The enzymatic pathways enabling a species to cope with oxidative stress are universal. Some of those enzymes are catalase (CAT), superoxide dismutase (SOD), peroxidase (PER) and glutathione peroxidase (GLU PER). We hope to measure these enzymes within *Artemia* to understand how *Artemia* handles this type of stress. We exposed *Artemia* to 0, 0.5, 1, 2, 5, and 10 ml of hydrogen peroxide

(H₂O₂) per 100 ml of seawater over the span of seven days. Mortality was 100% in shrimp exposed to 10 and 5 ml of H₂O₂ for the period of 72 h as well as those exposed to 2 ml by the seventh day. The survival rate was 100% for our control, 91.7% for 0.5 ml, 66.7% for 1 ml, and 8.3% for 2 ml when exposed for 3 days. We tested shrimp tissue samples for CAT, SOD, PER, and GLU PER concentrations utilizing spectrophotometry, polyacrylamide electrophoresis treated with enzymatic stains, and a general protein profile. A spectrophotometry assay for CAT showed no difference in activity between the samples. While the gels showed no definitive trend in any of the enzymes, PER showed bands 1.5× the strength of the controls on days 1 and 2 at 1 ml and 2 ml, respectively. The protein profile gave the best evidence for a trend at the increased concentrations. A protein of 40 kD increased noticeably on days 2 and 3. Currently, tests using primers to identify levels of gene expression are being performed to support or defy our observations. In the event that evidence mounts supporting a lack of activity in these known enzymes, continued research will be done into the presence of heat shock proteins and identifying other trends within the general protein profile.

POSTER

Sequence variation of the CytB gene in *Crocodylus acutus* populations in Pacific Costa Rica

Kyle Javenes, Jonathan Karpel, James Spotila, Laurie Mauger
Southern Utah Unveristy

Sequences of mitochondrial genes are useful in studying phylogeography and genetic differentiation in populations of threatened and endangered species. We determined the genetic structure of the American Crocodile (*Crocodylus acutus*) populations along the Pacific coast of Costa Rica for the CytB mitochondrial gene using the primer pair L14849 and H15453. Crocodile samples were collected from 11 localities along the Pacific coast of Costa Rica. Editing of sequences was done through BioEdit 7.0.9.0. Alignments were performed with ClustalW on Mega 7.0.18. We constructed neighbor-joining and maximum likelihood trees for the mitochondrial regions. We estimated the mitochondrial divergence across geographical locations for crocodiles in pacific Costa Rica. Preliminary data support minimal divergence and independent evolution in the sampled populations. A total of 8 haplotypes were sequenced.

POSTER**Utilization of complementary and alternative medicines to remedy stress by Utah Valley University students**

Cassandra Fenton, Sean Finley, Cherice Neeley, Jordan White
Utah Valley University

Complementary and alternative medicines (CAM) have been utilized throughout human history as a primary way to treat illness and encourage health and well-being. CAM is a group of health-related systems that is used other than mainstream health care. CAM focuses on the individual by promoting preventative practices and self-care. Despite the positive nature of CAM, the development of modern synthesized medications has caused people to abandon traditional CAM medicines. As the world becomes a more stressful place to survive in, people have developed personal ways to counteract stress. One of the most stressful environments for adults in the United States is college, because of the pressures of students to perform well on examinations and assignments. Because of this, we evaluated the ways in which Utah Valley University (UVU) students deal with their stress, particularly whether they use complementary and alternative medicines. For this research, semi-structured interviews with consent were conducted on 60 randomly chosen UVU students, ages 18–64 years, to record their ways of remedying stress. The results of these interviews were recorded and analyzed to determine what the most common type of CAM is used, such as a type of plant or activity, and the efficacy of using CAM to deal with stress. Our null hypothesis is that students do not use CAMs to deal with their stress.

POSTER**GM detection technologies and GM adoption in different markets: A literature review**

Jordan Byrd and Pauli Alin
Utah Valley University

Many genetically modified (GM) organisms are currently allowed to be grown and sold in markets such as Canada, India, New Zealand, and the United States. For more markets to adopt the legal and institutional frameworks under which GMs are allowed to be grown and sold, GM-

based food/feed products should increase their traceability (i.e., so one could trace a product to its source). To achieve traceability, GM content has to be reliably detected from each food/feed product. While a number of GM detection methods currently exist (e.g., PCR, DNA walking, biosensors, ELISA, immune-PCR), there is relatively little research on whether the usage of a particular GM detection technology might be better suited to increase the adoption of legal and institutional frameworks that would allow GMs to be grown and sold. To begin to address this lack of research, this paper uses a narrative literature review method to synthesize recent research on GM detection technologies and legal and institutional frameworks governing GM adoption. The synthesis will contribute to the emerging interdisciplinary literature on GM detection technologies and public policy.

POSTER

Synergistic efficacy of amphotericin B and essential oils against fungal strains known to cause mucormycosis

Karaleen Anderson and Dr. Olga Kopp

Utah Valley University

Mucormycosis is the third most common invasive fungal infection after candidiasis and aspergillosis. Because of the severity and the high mortality rate of this infection, the disease is considered to be highly important and emerging. The current use of amphotericin B to treat mucormycosis can have many adverse side effects, including chills, fever, headaches, loss of appetite, muscle pain, nausea, and weight loss, as well as fatal syndromes such as hepato- and nephrotoxicity. Because of these adverse effects, it is important to study new compounds that have potent antifungal application. An intriguing possibility is the combination therapy of amphotericin B with essential oils. This combination could potentially allow clinicians to lower the dose of amphotericin B, thus reducing the side effects while still maintaining and utilizing the effective antifungal properties of both the oil and the drug. Essential oils and their antifungal properties have been thoroughly studied; however, little research has been done on the synergistic effect of essential oils and amphotericin B on the three most common species isolated in mucormycosis infections, namely *Rhizopus oryzae*, *Abisidia corymbifera*, and *Rhizomucor pusillus*. This study aims to investigate the possible synergistic effects between selected

essential oils and the antifungal compound amphotericin B in an effort to find alternatives for the high dose of amphotericin B that is currently used to treat mucormycosis.

POSTER

An analysis of the prevalence of essential oil use and its correlation with demographic factors

Hayden Kallas, John Horspool, Michael Dodson, Taylor Daniels
Utah Valley University

The population of Utah County has a reputation for the use of essential oils as alternatives or supplements to clinical medicine. Our study investigates the correlation of major demographic factors within this population with the use of essential oils to determine if there are any notable trends. Our study consists of 60 interviews with 30 conducted on Utah Valley University's campus and the other 30 conducted in public areas around Orem, Utah. The data was collected and converted into numerical values, which were analyzed using a variety of statistical tests. The results of this research will be presented by poster, correlating the demographics with the use of essential oils as complementary and alternative medicine.

POSTER

Effect of religious authority on acceptance of evolutionary theory

Hendrik Ombach, Eric Trost, Aaron Ashley
Weber State University

In religious contexts, God is viewed as an ultimate authority, leading many people to look to religious leaders and scripture as a source of knowledge. Consequently, many religious individuals are resistant to epistemological systems (e.g., scientific methods) that are in direct conflict with their religious beliefs. Because of the direct conflict with the creation story in the opening chapters of Genesis, the theory of evolution may be especially hard for religious individuals to accept. This study examined changes in acceptance of evolution due to statements endorsing evolution made by religious authorities that

adhere to common religious denominations within the United States. These religious authorities include the Pope of the Catholic Church as well as 13,360 U.S. Christian leaders who have signed “The Clergy Letter,” an open letter advocating for evolution. In this study, participants completed the Inventory of Student Evolution Acceptance (I-SEA) to assess acceptance of evolution, followed by understanding of natural selection using the Conceptual Inventory of Natural Selection (CINS). Subsequently, participants were randomly assigned to an authority condition where they were given the pro-evolution statement from the religious authorities or an unrelated article serving as a control. Following the authority condition, participants were shown either videos explaining the evidence for evolution or an unrelated video as control. Acceptance of evolution was then again assessed via the I-SEA to test for changes in acceptance. It is expected that participants will be more accepting of evolution as a function of the religious authority appeal and that evidence will not be a successful method to increase acceptance of evolution.

POSTER

Effects of genetically vs non-genetically modified baby food on fruit flies

Donal Long Jr and Jaron Matsunaka

Southern Utah University

Genetically modified organisms (GMOs) are a hot topic of debate in political circles as well as the general population. There is no consensus on the safety of these products and research performed on GMOs is generally geared toward their agricultural efficacy rather than safety. There is mounting evidence in the emerging realm of epigenetics that dietary patterns can affect multi-cellular organisms on the phenotypic level. This project was designed around this concept, with fruit flies being chosen because of their gene similarities to humans. Baby food was selected as the food of choice because of its implications on the essential development of the infant. Three treatment groups (flies fed on USDA organic soybean medium, flies fed on USDA organic soybean media with the addition of non-GMO baby food, and flies fed on USDA organic soybean media with the addition of GMO baby food) that each contained ten replicates were cultured. Behavioral traits were assessed for each treatment group and were indicated as cocoons formation, mortality, and flies emerged.

POSTER**Use of fish oils in complementary and alternative medicine**

Riley Bastian, Allen Carlson, Jake Wood, Dr. Olga R. Kopp
Utah Valley University

Fish oils contain two specific types of omega-3, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), which are both polyunsaturated fatty acids. These fatty acids make up some of the main health benefits from fish consumption. Fish oils are commonly used in many fields of medicine; they are recommended by physicians and dietitians as a form complementary and alternative medicine to treat many different ailments and disorders. Notable benefits of consumption of EPA and DHA include decreased mortality due to coronary heart disease, maintained normal brain and visual function, and decreased joint pain due to arthritis, among other possible benefits. This study was done to assess of the demographics, uses, popularity and effectiveness of these oils in Utah and Salt Lake Counties. Samples were obtained for this study through an online questionnaire, which was submitted, at random, on various social media websites and email lists. Researchers are still gathering data to eliminate bias as much as possible; of the total respondents thus far (n=64), 73.4% (n=47) are from Utah County, 20.3% (n=13) are from Salt Lake County, and 6.3% (n=4) are from other counties, including out-of-state respondents. Some of the total participants, 57.8% (n=37), are taking or have taken fish oils previously. Participants have reported fish oil use for lower cholesterol, acne, dry eyes, heart health, joint pain, and better overall health. Dosage and compliance appear to be varied among participants. Final results will be presented.

POSTER**The effect of occupational licensing on women in Utah**

Jacob Caldwell, Colton Cowan, Olivia Mackelprang, Fiona Harrigan
Utah State University

All state governments require occupational licenses in order to work in certain fields. Previous research and economic theory suggest occupational licenses are used to restrict the entry of workers into a

chosen field, thus lowering the competition in a certain field. Though costly to the licensed businesses, the lowered competition results in the ability to charge higher prices, which may result in a net gain for the licensee. We collect, analyze, and create an index from data on Utah's licensed occupations to explore how occupational licensing affects women and minorities. In our ordinary least squares regression, we focus on price to submit an application, years of training, and cost of necessary exams to determine which fields were most impacted by occupational licensure. We then compare the data we used with the demographic data of workers in those fields. We find that women and minorities are disproportionately affected—meaning they bear more of the costs from occupational licensing than other segments of the population. This suggests laws meant to protect the population can sometimes come at the cost of other segments of the population.

SOCIAL SCIENCE

A survey of religion: Its development, neurophysiology, and current impacts

Bryan Casselman

Salt Lake Community College

There are few concepts that are as universal, dividing, and controversial as religion. It is hard to think of another mechanism that is so proficient at both bringing people together, and tearing them apart. Part of its controversial nature derives from the stark contrast in what religious and nonreligious people believe is the origin of the practice. Explanations for the practice range on a fairly large spectrum. On one side, explanations of religious people revolve around belief in the sacred histories found in their texts, claiming their faith was directly inspired by acts of God, or multiple Gods. On the other side of this spectrum, many nonreligious individuals believe it to be a man-made construction, some even going as far as to consider it a mental disorder. Within these two polarities are a myriad of voices, each having their own signature brand of mental gymnastics to resolve cognitive dissonance between faith and scientific discovery. Multidisciplinary research on religion, however, does not necessarily agree, nor contradict many of the most prevalent supporters and critics today. Instead, science paints religion as a complex byproduct of evolutionary mechanisms, refined through time via cultural narratives, physiological phenomenon, exposure to other cultures, and innovations in

technology. In this paper we will illuminate the historical and anthropological development of religion, examine its neurophysiological impact, and evaluate its psychological and sociological benefits to the individual, and its place in an increasingly secular society.

SOCIAL SCIENCE

“Determined to Make Righteous Homes”: LDS expressions of masculinity and family formation

Warren Jensen

University of Utah

In one of many webpages of its kind, “Why is family important?”, the Church of Jesus Christ of Latter-day Saints (LDS) explicitly emphasizes: “Let the young men lead,” suggesting the deep importance of specifically male leadership positions at all levels, from childhood upward. Many offices within the male-dominated offices of the priesthood (from Bishop onward) are defined by marital status as well as gender. For young men, achieving elder status (by completing a mission), getting married, and forming a family “one that is unified under the leadership of the father/husband” is seen as a process in defining an individual’s masculinity and his broader social status as a man. Despite this, literature on Mormon masculinity is relatively underdeveloped. In an effort to address this, my presentation will present original open-ended qualitative data gathered through focus groups with young LDS men between the ages of 20–30 years, an age cohort within the church that is often expected to complete missions and form families. Building off of qualitative data gathered in my focus groups and a content analysis of church documents and surrounding literature on the topic, I hypothesize that the achievement of certain indicators (elder status, marital status and family formation, etc.) inform the notion of more prestigious forms of masculinity for LDS men. Thus, I see pressure to perform “as a man” as a crucial factor that influences the lived experiences of “specifically young” LDS men, who are pursuing education, careers, and family, often within the social networks of the church. Thus, LDS constructions of masculinity uniquely emphasize family formation by linking it deeply to status indicators within the church; such an emphasis creates a “fast-track” effect, so to speak, in which young men experience exceptional

pressure not only to marry and have children but also to provide and establish their careers.

SOCIAL SCIENCE

Getting it right—A case study of a six-month sabbatical at home and abroad

Peter L. Kraus

University of Utah

Sabbaticals have long been part of the research culture in American higher education and academic libraries. A review of the scholarly literature shows that sabbaticals serve a number of purposes for librarians. By providing time for reviewing best practices at other libraries, working at other libraries within and outside the United States, or pursuing postgraduate degrees, sabbaticals have allowed those in academic libraries to improve their skill sets and knowledge base to improve themselves and their libraries. A successful sabbatical takes planning and focus; the author of the article will use his sabbatical, which took place between July and December 2015 in Salt Lake City, Utah, and St. Stephen's House, Oxford University, as model for this primer on having a successful sabbatical.

SOCIAL SCIENCE

Religious detachment among Utah Mormons: Does the internet play a role?

Rick Phillips

University of North Florida

Utah provides a natural laboratory for investigating the effects of demographic transition and technological change on religious identity and activity. Recent survey and polling data have revealed a rising trend in defection from religion in the United States. About one in five Americans now claim to have no denominational preference or formal church affiliation. Like most churches, The Church of Jesus Christ of Latter-day Saints (the LDS, or Mormon Church) has been affected by this trend. Studies show that between one fourth and one third of adults who say they were raised LDS no longer consider themselves members

of the church. This is up from around 10% a generation ago. Moreover, studies show that rates of defection from Mormonism are rising faster in Utah and the Intermountain West than in other parts of the United States. Two hypotheses have been put forward to explain this trend. The first is that new information technologies have lured certain members away from the church with attacks on Mormon history and theology. The second is that changing demographics in Utah have transformed the state's religious subculture, making it easier for less committed Mormons to leave the faith. This paper evaluates these hypotheses, and reinterprets of the meaning of data that seem to show that patterns of retention and disaffiliation among Utah Mormons are changing.

SOCIAL SCIENCE

Yoga and addiction recovery

Courtney Strong

Salt Lake Community College

The Yoga and Addiction Recovery Independent Study is a case study composed of surveys and observational research. The research and findings are documented here and presented in conjunction with a PowerPoint presentation. The study sampled 11 women living in a substance abuse recovery facility in Draper, Utah. The process analyzes practicing group yoga in a recovery setting and the effects of socialization on the group.

SOCIAL SCIENCE

The economic roots of political instability in the MENA region

Taylor Greenwell

Weber State University

The Middle East and North Africa region (MENA) has been characterized by significant political instability and is routinely ranked as the least peaceful region in the world. This paper argues that socioeconomic factors, rather than a desire for democratic institutions, are the primary driving force behind the chronic political upheaval

found in MENA. With the support of four case studies (Tunisia, Egypt, United Arab Emirates, and Saudi Arabia), this paper posits that economic liberalization, structural inadequacies in MENA economies, unemployment, and a “youth bulge,” as well as international financing practices are the main economic catalysts behind MENA’s political instability.

SOCIAL SCIENCE

Regressive effects of environmental regulation

Matthew Clint Bisbee and Michael Jensen

Utah State University

An affordable utility bill is considered to be no more than 6% of a person’s income. According to recent research, however, energy costs now represent 20% or more of income for many American families. The discussion of energy poverty is largely absent in the debate about America’s future, as the call to address climate change by reducing greenhouse gas emissions, at any cost, strongly influences policymakers. For families on fixed incomes, rising energy prices mean that the gap between what they can afford to pay and what they are paying for electricity is widening. Our research evaluates the regressive effects of environmental regulation by studying how such regulation impacts electricity prices, and, ultimately, household budgets.

SOCIAL SCIENCE

Populism and Power

Dallas Blackburn

Salt Lake Community College

Populism and Power examines the relationship between populist movements and political power in the United States. This idea is approached from a conflict theory perspective, which will inspect how different groups compete for the scarce resource of power. I will present a theoretical view of this relationship, which I call the populist power theory, and then apply this model to different populist movements: the People’s Party of the late 1800s and the modern Tea Party. The theory will attempt to explain how these past movements,

through competition with other groups, were able to achieve political power, and then in the case of the People's Party, how political competition ultimately led to their demise. I will also consider, in regards to the Tea Party, how this group has managed to overcome competition to continue to gain political capital. After these two examples are scrutinized within the bounds of the populist power theory, I will then apply this concept to the new populist Bernie Sanders movement, which movement I will address as Our Revolution. I will demonstrate how Our Revolution has thus far followed the same general formative path and trajectory of the two previously mentioned movements, and then postulate what the future of this movement is based on the history of these examples, whether the new movement is heading towards growth or collapse.

SOCIAL SCIENCE

Social policy: A guide for social scientists in the academy

Ty B. Aller and Kathy Piercy

Utah State University

As academic researchers, social scientists are among the most knowledgeable groups of citizens regarding social policy issues. Despite their expertise, many researchers do not engage in the legislative process to influence policy decisions. Reasons for this lack of engagement often include not fully understanding the legislative process or lack of confidence to effectively engage policy makers. To build researchers' understanding and confidence to influence social policy, this presentation draws on the experience of one social scientist's efforts to influence policy to improve college students' mental health. In detailing this social scientist's experience, this presentation briefly describes the legislative process in Utah and then provides suggestions on how social science researchers can more effectively engage in the policy making process. More specifically, this article focuses on the ten steps to civic engagement outlined by Graham and Hand (2009) by explaining three basic ideas: 1) identifying a problem and formulating a solution; 2) building support for your policy initiative; and 3) taking action by engaging constituents and policy makers. Suggestions on how researchers can use their expertise in conjunction with these three basic ideas to influence policy will be discussed.

SOCIAL SCIENCE

How does ranked-choice voting impact incumbents?

Logan Hemmert and Ryan Yonk

Utah State University

The exploration of electoral systems has long considered the impact that alternative voting systems could have on electoral outcomes. Alternative voting systems have long been assumed to impact electoral process, vote choice, and candidate success. Building on the earlier work and expanding the data used in “Trading places and Extreme Vote Makeover” by Yonk et al., we explore the impact of ranked choice voting in the City of Minneapolis, MN. In this paper, we examine the impact that instant-runoff voting has had on incumbency rates in Minneapolis. Using data from mayoral and city council election ballots in Minneapolis from 2013, we examine the impacts of ranked-choice voting on the engagement of elected officials and voters in the electoral process. It is well known that incumbents have many advantages over challengers, and systems like ranked-choice voting that take multiple voter preferences into account, may afford more protection to incumbents. Using the actual individual vote data for the city, we test that possibility empirically.

SOCIAL SCIENCE

A librarian runs for political office (or Cincinnatus looks outside the Ivory Tower)

Peter L. Kraus

University of Utah

Librarians have long been activists for social and political causes outside of their profession; however, few take the crucial step and actually run for political office at the local, state, or national level. In March 2014, after being involved in local and state politics for over 10 years and volunteering for political campaigns at the local, state, and national level, and with some encouragement from individuals I knew in political and academic circles, I threw myself into the political realm by registering to run as a (moderate) Republican for a House seat in the Utah Legislature. Little did I know that, as an academic librarian, this would be an incredible learning experience. I wish to emphasize that this is not an article on how to run for office (there are numerous

articles and books that discuss this subject). Rather this is an overview and case study of an academic librarian who became involved in the political process and exercised his right to run for office to represent the community in which he resides.

SOCIAL SCIENCE

The winner-take-all Electoral College

Jamie Nelson

Salt Lake Community College

In 1787, the Electoral College was created with the sole purpose of choosing the future Presidents of the United States. As the American political process has grown and changed, so has the Electoral College; what was once a system that favored the social and political elite is now primarily controlled by state partisanship and, to a lesser extent, public opinion. As we become a more democratic society, in which all adult citizens have the right to vote, some argue the Electoral College is an antiquated system that continues to favor the elite class above the voting public. This argument has been further supported by recent discrepancies between the popular vote and Electoral College results in the 2000 and 2016 presidential elections. However, states have dramatically changed the way electors are chosen in their state; the winner-take-all electoral system has dominated the preferred selection process and electors are expected to vote for the presidential candidate who won the popular election in their state. Because of winner-take-all electoral policies, the impact of an individual vote has been greatly diminished in states with one dominant party. This fact has significantly altered presidential campaigns and the subsequent success of certain candidates. Although most presidents have won both the Electoral College and the popular vote, many American citizens have called for an end to the Electoral College system and have supported a direct democratic election instead. Changing the process of electing the US President would require a constitutional amendment which is unnecessary, as statistical and historical evidence suggests the true “Electoral College problem” rests in the state governments that have create partisan policies and have diminished the value of an individual vote in their own states.

SOCIAL SCIENCE

Veterans' perception of the Department of Veterans Affairs

Catherine Stoddard, Barrett Bonella, and Corina Tadehara

Weber State University

When military personnel return from their service, they often experience a variety of medical, psychological, financial, social, and educational needs that are supposed to be met by the Department of Veterans Affairs (VA). The purpose of this study was to consider what the VA system looked like from veterans' points of view and how the VA helped shape their own self-perceptions as veterans. Ten veterans were interviewed using a set of 25 questions relating to their military service, their understanding of the VA healthcare system, and their own experiences with the VA. The interviews were recorded, transcribed, and later analyzed with the help of the program ATLAS.ti 7. Journals were also kept regularly to ensure objectivity and self-reflection were accounted for in the study. Issues such as trust, experiences with the health care system, positive and negative interactions with all aspects of the agency, and perception of themselves as priorities of the government were based on VA funding were discovered. The results indicate several areas in which the VA fails to provide quality services for veterans, though such failings are perceived to be results of antiquated policies, inflexible bureaucracy, and politically low prioritization of veterans after they've done their part as soldiers.

SOCIAL SCIENCE

Space-time signatures in laws, societies and conflicts

Shadman Bashir

Dixie State University

The term space-time is used in physics and mathematics to identify a model that combines space and time into one single interlinked sequence. Space-time is not just a logical and scientific creature limited to the study of extra dimensions or the geometry of subatomic particles in quantized space-time. It is a logical primer that is fundamental to the study and proper understanding of many of the most complex and controversial issues present within traditionally nonscientific academic fields. The space-time primer can be used to understand and classify

diverse issues ranging from contemporary suicide bombings to the legality of the relationship between Romeo and Juliet, from divine dogma to the logic of atheism, from the Eighth Amendment of the United State Constitution to the legal status of punishment by stoning to death and many more. There are distinct space–time signatures stamped as footnotes on every human social practice throughout our history, and we in most cases try to understand the practice without reading the signature. This paper is a brief introduction and explanation of the application of space–time signatures in academic fields including but not limited to law, history, politics, crimes and conflicts.

SOCIAL SCIENCE

How does materialism influence financial problems in marriage?

Hannah-Lee Brau

Brigham Young University

In this paper, I first analyze the research findings of two academic studies, providing details and findings. In the second section, I summarize two magazine articles that give practical counsel for marriage. In the third section, I provide a discussion of the correlation between these two sources of knowledge. In the first article, “Materialism, perceived financial problems, and marital satisfaction,” by Dean, Carroll, and Yang (2007), the topics of materialism and marriage are carefully studied. The authors specifically study three research questions: 1) Is spousal materialism associated with the relative frequency with which spouses perceive financial matters to be a problem in their relationship? 2) Does the strength of the association between perceived financial problems and marital satisfaction differ for materialistic and nonmaterialistic spouses? and 3) Do spouses’ levels of materialism affect couple reports of financial problems and marital satisfaction? The second article, “Materialism and marriage: couple profiles of congruent and incongruent spouses” by Carroll et al. (2011), is more succinct than the first article because it is an extension of the first article and deals with similar key variables and theory. The authors extend the first article because the study did not consider spouses’ materialism in relation to their partners’ materialism. Two additional research questions are posed: 1) Are spouses’ levels of materialism significantly related to one another and to what degree do married couples exhibit congruent or incongruent patterns of materialism? and 2)

How are couple patterns of congruence or incongruence in spousal materialism associated with marital characteristics and outcomes?

SOCIAL SCIENCE

Implementing CUR recommendations: Expanding the high-impact practice of undergraduate research within the curriculum

Chantelle Shapcott, Justin Felkins, Brooke Bradford, Jessica Hill, and Bryan Dalley

Utah Valley University

Although Utah Valley University implements most of the 10 high-impact practices suggested by the College Association of American Colleges & Universities, there is a weakness associated with the implementation of undergraduate research. We implemented a large-scale, faculty-supervised model of scholarship with a peer-mentorship component. The present project recruited a subset of 25 at-risk PSY1010 students enrolled in a large hybrid section over Spring 2016. During the off-day for the hybrid course, students met with a peer-mentor to learn the basics of researching human behavior. Throughout the semester, students conducted four mini-projects that allowed them to explore their own critical questions and ideas within specific boundaries. Two higher-achieving junior/senior behavioral science students were compensated to act as mentors to at-risk students. The mentors met individually with each of their 12–15 students for an hour during the week to assist them with coursework for either course or research. Moreover, we implemented the same scholarship model with another 25 at-risk PSY1010 students within a large hybrid section over Fall 2016. Throughout Fall 2016, students conducted the same projects without the influence of peer-mentorship. In order for retention efforts to be more effective, they must go beyond mere social support from student affairs programs to include active academic support, such as peer mentorship. We propose that introducing peer mentorship in general education classes will yield greater student retention, particularly for at-risk students. Moreover, we predict combining undergraduate research experiences with peer-mentorship will produce transferrable academic skills. Lastly, it is our intent to model self-regulation of learning through early, high-impact interventions.