

The Journal of the
**Utah Academy of
Sciences, Arts, & Letters**
Volume 92 • 2015

**Includes selected and refereed articles from the
2015 Annual Conference
held at
Snow College
March 27, 2015**

Editor
Kristin L. Kraus

Copyright 2016, 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: 978-0-9815501-9-0

All Rights Reserved

Board of Editors

Arts: **Angie Banchem-Kelleher**, Utah Valley University
Biological Science: **Laurie Mauger**, Southern Utah University
Business: **Douglas Peterson**, Westminster College
Education: **Laura Snelson**, 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:
David Richter, Utah State University
Letters—Language and Literature: **Keith Lawrence**, Brigham
Young University
Physical Sciences: **Rico Del Sesto**, Dixie State University
Social Science: **Rachel Hayes-Harb**, University of Utah
Posters: **R. Steven Turley**, Brigham Young University

2014-2015 Utah Academy of Sciences, Arts, & Letters Officers

President: **Jonathan Westover**, Utah Valley University
President-Elect: **H. Laine Berghout**, Weber State University
Past President: **Erin O'Brien**, Dixie State University
Secretary: **Susanna Garcia**, Utah Valley University
Treasurer: **Karl Israelsen**
Scholarly Communications: **Peter Kraus**, University of Utah
Member at Large: **Dwight Israelsen**, Utah State University
Technology Officer: **Rachel Ramsey**, Dixie State University

Cover Photo: Courtney R. Davis, “The Intellectual Simulacrum:
Landscape Photography, Copyright Law, and Claiming the American
West,” p. 19

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—2015**

AWARDS

| | |
|------------------------------------|-----------|
| Distinguished Service Award | 11 |
| Academy Fellow 2016 | 12 |
| Tanner Lecture | 13 |
| John and Olga Gardner Prize | 14 |
| Honorary Member 2016 | 15 |
| 2015 Best Paper Awards | 17 |

ARTICLES

ARTS

| | |
|--|-----------|
| The Intellectual Simulacrum: Landscape Photography, Copyright Law, and Claiming the American West | 19 |
| Courtney R. Davis, <i>Utah Valley University</i> | |
| Sociopolitical Influences on the Creation of the Ballet <i>Giselle</i> | 33 |
| Rose Hutchins, <i>Utah Valley University</i> | |
| The Symphony and the Ballet: Select Compositions of Tchaikovsky as an Educational Tool for Music and Ballet | 47 |
| Justine Sheedy-Kramer, <i>Utah Valley University</i> | |

BIOLOGICAL SCIENCES

- Effects of mercury (II) chloride exposure on life parameters and Hsp70 expression in brine shrimp *Artemia franciscana*** 67

Dustin Ingraham and Nicole Berthélémy, *Weber State University*

- The PhD Labor Market Imbalance and its Effect on Life Science Departments** 81

Jonathon C. Marshall,¹ Nile Carrethers,¹ Tyson Schwab,² Geoff Beck,³ and Leticia Alvarez Gutiérrez², ¹*Weber State University*; ²*University of Utah*; ³*Saint Louis University*

BUSINESS

- Exploring comparative employee engagement** 89

Aaron Barros, Sean Costello, Garret Beaman, and Jonathan H. Westover, *Utah Valley University*

- Accounting for Virtual Currency Transactions** 109

Jennifer Harrison and Ronald Mano, *Westminster College*

- An Exploratory Investigation of Gender and Cross-Major Differences in Business Student Success in an IT Course** 119

Taowen Le,¹ Jin Zhang,² and Wayne Wei Huang³, ¹*Weber State University*, ²*University of Wisconsin Milwaukee*, ³*Ohio University*

EDUCATION

- NSSE as an Institutional Assessment Tool: Increasing Response Rates and Student Awareness** 145

Angela Ward, Laura Snelson, Nikole Higgins, and David Anderson, *Utah Valley University*

ENGINEERING

- Hybrid Wind and Solar Electric Power System** 157
Doran Baker and Gene Ware, *Utah State University*
- Space Dynamics Laboratory: An Unexpected Success** 163
Brian Simons and Doug Lemon, *Utah State University*

EXERCISE SCIENCE AND OUTDOOR RECREATION

- The 2014 Olympic Winter Games as a Catalyst for Physical Activity** 173
James Bemel, *Utah Valley University*

LETTERS—HUMANITIES, PHILOSOPHY, AND FOREIGN LANGUAGE

- Attitudinal Shifts in Student Perceptions of Academic Service-Learning: An Exploratory Study of a General Education Humanities Course** 191
Kimberli M. Lawson, *Utah Valley University*
- Collaboration and Performance in the Pessoa/Queiroz Love Letters** 203
Todd Kimball Mack, *Southern Utah University*

PHYSICAL SCIENCES

- Qualifying and Quantifying the Uncertainty in the Heisenberg Uncertainty Relations** 223
Jacob “J” Collings and Jean-François S. Van Huele, *Brigham Young University*

**Determining Thin-Film Roughness with Extreme
Ultraviolet Reflection** **239**

Cody L. Petrie, Joshua Marx, David Squires, and R. Steven Turley,
Brigham Young University

**Phosphatidylserine–Copper (II) Binding Can Lead to Fast
Through-Membrane Copper Transport** **257**

Michael J. Trujillo, D. Tyler Scholes, Christopher M. Reynolds,
Conner Winegar, and Christopher F. Monson, *Southern Utah
University*

SOCIAL SCIENCES

Undercover Policing: Practices and Challenges **273**

Lindsey Bonney, *Weber State University*

**Anne Teresa De Keersmaecker's *Violin Phase* from a
Jungian Perspective** **285**

Jon Thomas, *Utah Valley University*

ABSTRACTS **297**

DISTINGUISHED SERVICE AWARD

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

Richard R. Sudweeks

*Professor of Instructional Psychology and Technology
Brigham Young University*

Richard Sudweeks is a professor in the Department of Instructional Psychology and Technology at BYU. He also serves as the director of the Ph.D. program in Educational Inquiry, Measurement, and Evaluation in the David O. McKay School of Education. Dr. Sudweeks received his Ph.D. in Educational Psychology from the University of Illinois at Urbana-Champaign in 1978 with a specialty in the educational measurement and program evaluation. During his years at Illinois, he worked as a research assistant in the Center for Instructional Research and Curriculum. His primary mentors were professors Robert Stake, J. Thomas Hastings, Robert Linn, and Maurice Tatsuoka.

After completing graduate school, Dr. Sudweeks was employed as Director of Evaluation in the Center for Instructional Development at Syracuse University in upstate New York, where he was responsible for overseeing the evaluation of courses and innovative instructional programs on campus. He came to BYU in 1980 and spent three years working in similar role evaluating innovating courses and curricula. He completed numerous course evaluations at this time, but the main one was an extensive evaluation of the Freshman English courses at BYU, which enrolled over 2,000 students per semester in more than 80 sections.

In 1983, Dr. Sudweeks became a full-time faculty member at BYU. He has spent the last 32 years teaching graduate courses in educational measurement, statistics, and research design. For 24 years, he taught a graduate course focused on methods for assessing how well students have acquired the intended learning outcomes of courses including affective, behavioral, and higher-level cognitive outcomes. Since becoming director of the Ph.D. program in Educational Inquiry, Measurement, and Evaluation, he has focused more on teaching courses in research design and psychometrics including factor analysis and item response theory.

ACADEMY FELLOW 2016

Jean-François Van Huele

Brigham Young University

Jean-François Van Huele is Associate Professor in Physics and Astronomy at Brigham Young University. He was born in Ostend, Belgium. He studied physics at the Vrije Universiteit Brussel in Belgium, where he earned his undergraduate degree in physics, his teacher's proficiency certificate, and his doctoral degree in science on the subject of quantum electrodynamics. He has published in theoretical particle physics, atomic physics, condensed matter physics, and mathematical physics. Currently, his main fields of interest are quantum dynamics and quantum information science.

Jean-François joined the faculty at Brigham Young University in 1988, attended his first Utah Academy Conference in 1991, presented his first paper at a UASAL conference in 1992, and published his first paper in JUASAL with his very first graduate student, Steven Sullivan, in 1994. Since then, he has been a regular attendee and contributor at Utah Academy conferences and an enthusiastic participant at Academy excursions and events. He served as Chair of the Division of Physical Sciences for the Utah Academy from 2005 until 2013.

Dr. Van Huele is active at the national level of the American Physical Society, where he served as chair of the committee on constitution and bylaws, and in its regional Four Corners Section, where he currently serves as vice chair. He is also active at the national and regional levels of the American Association of Physics Teachers. Recent and long-time favorite professional activities include mentoring summer research experiences for undergraduates, whom he introduces to Utah; teaching physical science to non-majors; and developing and teaching advanced writing courses in physics.

In his free time, Jean-François likes to hike the beautiful Wasatch Mountains between Lone Peak and Mount Nebo, watch birds anywhere around Utah Lake, and travel to Central America, where he likes to introduce elementary school children to science concepts with simple demos.

O.C. TANNER LECTURE

AMAZING REALIZATIONS: SURPRISED BY OPPOSITES THAT ARE NOT OPPONENTS

Jack Welch

*Robert K. Thomas Professor of Law
J. Reuben Clark Law School
Brigham Young University*

John W. Welch is the Robert K. Thomas Professor of Law at the J. Reuben Clark Law School, where he teaches a variety of courses on tax-exempt organizations, ancient laws in the Bible and Book of Mormon, and Joseph Smith and the law. He was educated at Brigham Young University with a B.A. in History and M.A. in Classical Languages (1970), filled a Latter-day Saint mission in South Germany (during which time he discovered chiasmus in the Book of Mormon), studied Greek philosophy at Oxford University (1970-72), served on the Duke Law Journal and earned his law degree at Duke University (1972-75), and practiced tax law in the Los Angeles firm of O'Melveny and Myers (1975-1980), before joining the faculty at BYU.

He is well known as the founder of FARMS (the Foundation for Ancient Research and Mormon Studies), and since 1991, as the editor-in-chief of BYU Studies, the leading interdisciplinary journal at BYU. He also has served as the general editor of the Collected Works of Hugh Nibley, as a member of the Jewish Law Association, and on board of editors for Macmillan's Encyclopedia of Mormonism. He was the Distinguished Faculty Lecturer at BYU in 2010.

He has authored or edited a number of books and articles, including *The Sermon on the Mount in the Light of the Temple* (London: Ashgate, 2009); *The Legal Cases in the Book of Mormon* (Provo: FARMS, 2008), and *Sustaining the Law: Joseph Smith's Legal Encounters* (Provo: BYU Studies, 2014). In other notable works, he has analyzed the hidden allegorical meanings in the parable of the Good Samaritan, the legal elements of fear and miracles in the trials of Jesus, the expanding mind, the foundations of jurisprudence, the conjunction of rights and duties, the role of evidence in the nurturing of faith, and the forging of a friendly alliance between science and religion.

He is married to Jeannie Sutton, who recently retired from the French Department at Brigham Young University. They have four children and seventeen grandchildren. Together they enjoy traveling, teaching, family activities, the arts, and church service.

JOHN & OLGA GARDNER PRIZE

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

Don Leslie Lind

Utah State University

Originally from Midvale, Utah, Dr. Lind attended the University of Utah, graduating with a degree in Physics in 1953. As a Naval Aviator, he held the rank of Commander in the Naval Reserve and logged more than 4,500 hours of flight time with 4,000 in a jet aircraft. While he was serving in the Navy, he volunteered to take photo emulsions on his flights to record cosmic rays for University of California, Berkeley, scientists. He completed his Ph.D. in High Energy Nuclear Physics in 1964 at Berkeley.

Dr. Lind went on to work for NASA at the Goddard Space Flight Center in Maryland starting in 1964 as a space physicist. He worked on research on low-energy particles in both the magnetosphere and interplanetary space and ultimately served as a member of the fifth group of NASA astronauts selected in 1966. He worked on the development of lunar surface tools for the Apollo program. He was a member of the Astronaut Office's Operations Missions development group as part of the Space Shuttle program and developed payloads for early missions. He finally became a flight crew member for Mission STS-51-B in 1985, serving as Mission Specialist. After retiring from NASA in 1986, he joined the faculty at Utah State University to teach physics, astrophysics and astronomy for nine years. Dr. Lind was awarded the NASA medal for Exceptional Service in 1974.

HONORARY MEMBER 2016

Doug Fabrizio

Host/Executive Producer, Radiowest

Doug Fabrizio has been reporting for KUER News since 1987, and became News Director in 1993. IN 2001, he became host and executive proucr of KUER's RadioWest, a one-hour conversation/call-in show on KUER 90.1 in Salt Lake City. He has gained a reputation for his thoughtful style. He has interviewed everyone from Isabel Allende to the Dalai Lama, and from Madelaine Albright to Desmond Tutu. His interview skills landed him a spot as a guest host of the national NPR program, "Talk of the Nation." He has won numerous awards for his reporting and for his work with RadioWest and KUED's Utah NOW from such organizations as the Society of Professional Journalists, the Utah Broadcasters Association, the Public Radio News Directors Association, and the Academy of Television Arts and Sciences.

2015 BEST PAPER AWARDS

Art

Sociopolitical Influences on the Creation of the Ballet *Giselle*

Rose Hutchins

Utah Valley University

Business

An Exploratory Investigation of Gender and Cross-Major Differences in Business School Success in an IT Course

Taowen Le,¹ Jin Zhang,² Wayne Wei Huang³

¹*Weber State University*, ²*University of Wisconsin Milwaukee*, ³*Ohio University*

Education

NSSE as an Institutional Assessment Tool: Increasing Student Response Rates

Angela Ward

Utah Valley University

Letters—Foreign Language, Humanities and Philosophy

Collaboration and Performance in the Pessoa/Queiroz Love Letters

Todd Kimball Mack

Southern Utah University

Letters—Language and Literature

Influenza, Heritage, and Magical Realism in Katherine Anne Porter's Miranda Stories

Katherine Nelson

Brigham Young University

Physical Science

Patterning Supported Lipid Bilayers Using Magnetic Tweezers

Travis Bulloch, Christopher Monson, Tyler Argyle

Southern Utah University

Social Science

Anne Teresa De Keersmaecker's *Violin Phase* From a Jungian Perspective

Jon Thomas

Utah Valley University

The Intellectual Simulacrum: Landscape Photography, Copyright Law, and Claiming the American West

Courtney R. Davis

Utah Valley University

Abstract

During the second half of the nineteenth century, explorer-photographers produced negatives and photographic plates of the American West by the tens of thousands, whether as part of government-backed expeditions or on their own private excursions. This paper proposes that while such photographers documented the West for scientific and aesthetic purposes, photography also was used as a method to control and even to commoditize the western American landscape. Through the use of the camera, photographers staked a visual, psychological, and intellectual claim over the West. Copyright registration legitimized such claims, having first been expanded to cover photographs and photographic plates under the Copyright Act of 1865. The photograph, as a product of modern technology, became both a commodity and a symbol of the power and dominion of the prevailing culture. Landscape photographs functioned as a miniature

of reality, and in this intellectual simulacrum, explorers colonized every detail of the western landscape, visually claiming not only terrain and topography, but also aesthetics and intellectual property.

During the second half of the nineteenth century, scientific and photographic expeditions abounded in the western United States. From large-scale, government-backed expeditions, like the Hayden and Wheeler Surveys, to more intimate, self-funded explorations, photographers produced negatives by the tens of thousands. Often shouldering great physical risk to obtain the perfect view, the explorer-photographers earned immediate admiration with their images of the wilds of the American West, from Yosemite to Yellowstone, the Sierra Nevadas to the Rockies. But the frontier photographers did more than capture the sublime wonders of hitherto unseen panoramas: They charted the American West visually, bringing landscape under the control of modern technology. By transforming landscape into a fixed image, western landscape photographers staked a claim of visual ownership through the auspices of intellectual property law.

This paper proposes that frontier surveyors used photography as a method to control and commoditize the western American landscape and that such images contributed to the taming of the West through industrialized technology. Statutory and case law, such as the Copyright Act of 1865, which extended copyright protection to photography, and the landmark case that followed, lend support to these arguments. In the framework of intellectual property, the landscape photograph functioned as a “miniature of reality,” to borrow a phrase from Roland Barthes, and in this intellectual simulacrum, explorers colonized every detail of the western landscape, visually claiming not only terrain and topography, but also aesthetics and intellectual property.

Claiming the Visual: U.S. Copyright Law

United States copyright law developed within a framework of flux and evolution inextricably connected to changes in technology and the value of intellectual property. While the idea of intellectual property rights can be traced back to the Renaissance, the coalescence of these ideas emerged in seventeenth- and eighteenth-century England, as literary publishers and booksellers vied for control over printing rights

and the book trade.¹ The British Statute of Anne was passed in 1710 to curb the monopolization of book publishers and sellers. The Engraver's Act, for which artist William Hogarth valiantly lobbied, was passed by Parliament in 1735 to afford similar protections to printmakers.

The theory of the Statute of Anne was imported to America and found a home not only within early state statutes, but also within Article 1, Section 8, Clause 8 of the United States Constitution, which empowers the United States 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 Copyright Act of 1790, signed into law by President George Washington, was the first federal copyright law enacted in the United States under the U.S. Constitution. Limited to maps, charts, and books, the 1790 law, a product of the Enlightenment, focused on literary works and the rights of authorship. In the words of Oren Bracha, Assistant Professor at the University of Texas School of Law, "Authorship was understood as the process by which an individual spirit served as the ultimate source of new original ideas."² Even so, the 1790 Act was not entirely amenable toward such lofty original ideas. Unlike the "life plus 70 years" clause of today, the original law gave protection only for a 14-year term, with the possibility of an additional 14-year extension. The application procedures were far from simple, requiring a record filed with a district court clerk, a sixty-cent fee, and publication for four weeks in a newspaper printed within the United States. Because of these onerous conditions, only about 5% of works published in the U.S. between 1790 and 1800 were actually registered under the Act.³

But over the course of the nineteenth century, copyright law would gradually change. In 1802, prints were added to the list of protected works, and music in 1831, the same year in which the original 14-year term would be extended to 28 years, with the possibility of a further 14-year extension. Dramatic compositions were added in 1856, and in 1865, photographs and photographic negatives. The law was overhauled in 1870, with works of art being added,

¹ Oren Bracha, "The Ideology of Authorship Revisited: Authors, Markets, and Liberal Values in Early American Copyright," *The Yale Law Journal* 118, no. 2 (2008): 192.

² *Ibid.*, 198.

³ Jeremy Byellin, "Legal Research: Thoughtful Articles About Legal Research and Solutions," *Legal Solutions Blog*, 31 May 2013, <http://blog.legalsolutions.thomson-reuters.com/legal-research/today-in-1790-the-first-federal-copyright-act-is-signed-into-law/>

including paintings, drawings, and sculptures. During this era, the U.S. Supreme Court adjudicated only a handful of copyright cases, most of which pertained to literary works. However, one landmark case still cited in contemporary copyright actions and legal casebooks addressed visual copyright directly: *Burrow-Giles Lithographic Co. v. Sarony* (1884), which upheld the constitutionality of the 1865 Act extending copyright protection to photography.

At issue in *Sarony* was the photograph “Oscar Wilde No. 18” (fig. 1), taken in 1882 by Napoleon Sarony, a prominent New York-based celebrity photographer who specialized in popular *cartes des visites*. The Burrow-Giles Lithographic Company made a staggering 85,000 copies of the image, and Sarony justly brought suit for copyright infringement. Defendant Burrow-Giles fired back, arguing not only that Sarony had not followed the correct copyright procedure, but above all, that photographs simply could not be protected by copyright law in the first place, because photographers were not “authors.”



Fig. 1. Napoleon Sarony, “Oscar Wilde No. 18.” 1882.

The case brought into question the very nature of photography—was it simply the dehumanized product of a machine? Or was it, in fact, mediated by the artistic skills and vision of a photographer–creator–author? Christine Haight Farley, Assistant Professor of Law at the American University Washington College of Law, has written at length on the subject. Farley has asserted, “When photography was first invented, it was explicitly promoted as being a mechanical science

whereby the machine was able to produce a direct transcription of the scene before it.”⁴ This squares with the growing use of photographs as legal evidence: “the prevailing judicial approach to the photograph was to align it, by analogy, with maps, models, and diagrams.”⁵ But in the *Sarony* case, Farley asserted that the “Supreme Court concluded that another reading of photography was in fact possible. *This* work, said the Court, was clearly the work of an author, not a machine. *This* work was not an example of the ‘ordinary’ production of a photograph.”⁶

Legal historians have noted that, while the *Sarony* holding has been used to support the copyrightability of all photographs, that premise was not necessarily the ruling of the Court. *Certain* photographs possess the qualities aligned with “original authorship.” But, as noted by Justin Hughes, Professor at the Cardozo School of Law, the personal creative decisions related to staging, lighting, settings, timing, viewpoint, and so forth, can and are used as necessary evidence of creative authorship.⁷ Under this approach, even documentary and non-figural works fit comfortably within the purview of copyright law, even without elaborate studio sets, posing, and arrangements. Indeed, post-1865 and particularly post-*Sarony*, landscape and architectural photographers began copyrighting their images to afford the same protection as studio-produced works. In 1894, approximately 5,045 photographs were registered with the Copyright Office, a number that jumped to nearly 15,000 by 1900.⁸

Copyright and Commodity: Taming the West

This expansion of photographic copyright registrations reflects the spirit of the nineteenth century, which was as a whole, an era of

⁴ Christine Haight Farley, “The Lingering Effects of Copyright’s Responses to the Invention of Photography,” *University of Pittsburgh Law Review* 65 (2005): 389.

⁵ Justin Hughes, “The Photographer’s Copyright—Photograph As Art, Photograph as Database,” *Harvard Journal of Law & Technology* 25, no. 2, (2012): 346; citing Jennifer L. Mnookin, “Images of Truth: Photographic Evidence and the Power of Analogy,” *Yale Journal of Law & Humanities* 10, no. 1 (1998): 43.

⁶ Farley, 389.

⁷ Hughes, 356.

⁸ Statistics for the year 1894 are approximate, calculated by the author by consulting the *Catalogue of Title Entries of Books and Other Articles Entered into the Office of the Librarian of Congress at Washington Under the Copyright Law*, Nos. 131-184 (Washington: Government Printing Office, 1894). Statistics for 1900 compiled through the *Catalogue of Title Entries of Books and Other Articles Entered into the Office of the Librarian of Congress at Washington Under the Copyright Law*, vols. 22-25 (Washington: Government Printing Office, 1900).

discovery, exploration, and invention, with the law expanding and contracting to meet the new demands of technology. Nowhere was this more evident than in the American West—the rugged and sublime terrain claimed by hardy settlers, explorers, traders, pioneers, and prospectors, often wielding the banner of Manifest Destiny. A new and rapidly improving technology, the camera became an indispensable tool for western explorer-photographers, for whom the photographic negative was a form of visual mapping and scientific record-making, as well as an expression of artistic vision. But during the taming of the West, landscape photography had dual purpose—not only of capturing the grandeur of western nature for historical, scientific, and aesthetic purposes, but also of wielding control, of asserting hegemony over the landscape itself and its occupants. Alan Trachtenberg, focusing on the government-sponsored western surveys, asserted that photographic images “contributed to the federal government’s policy of supplying fundamental needs of industrialization, the needs for reliable data concerning raw materials, and promoted a public willingness to support government policy of conquest, settlement, and exploitation.”⁹ Scholar Steven Hoelscher has similarly stated, “the photographic view was a powerful American tradition, tightly bound to larger forces of American capitalism and imperialism as the country stretched into new territories, organized and measured the land, colonized space, and transformed the landscape.”¹⁰ The sheer number of photographic plates and negatives from the western expeditions alone supports this theory. William Henry Jackson (1843–1942), for example, accompanied the Hayden Expedition to Colorado, producing thousands of stereoscopic views; the Colorado Historical Society alone has nearly 8,000 glass plates from this trek.

The photograph thus functioned as visual evidence supporting expansionist ideologies. After all, sight, according to Michel Foucault, is a privileged sense, “being the sense by which we perceive extent and establish proof, and in consequence, the means to an analysis *partes extra partes* acceptable to everyone.”¹¹ Landscape photographs provided this proof because of their inextricable links to reality. Even before photography was afforded copyright protection, photographs

⁹ Alan Trachtenberg, *The Incorporation of America* (New York: Hill and Wang, 1982), 20.

¹⁰ Steven Hoelscher, “The Photographic Construction of Tourist Space in Victorian America,” *Geographical Review* 88 (1988): 551.

¹¹ Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (New York: Vintage Books, 1970), 133.

were ruled as admissible evidence in certain courts of law, because of the nineteenth-century mindset that photography was an objective and honest reproduction of reality.¹² It was not until the twentieth century that the term ‘documentary photography’ was used to separate this approach from photographs that could be manipulated.¹³ But even today, when photographs are almost never left untouched, photography is still often viewed as a self-proving law or an indexical sign—something that records its own making. In the words of Roland Barthes, “It is as if the Photograph always carries its referent with itself.”¹⁴

For private enterprise, the evidentiary nature of photography took a different form, one related to ownership and intellectual possession. Exposed photographic plates were a commodity in the late nineteenth century, and copyright law offered a way to protect that commodity. Indeed, the primary purpose of a copyright is to protect a work from unauthorized reproduction in the marketplace: “authors” are afforded protection of their creation for a limited period of time. By copyrighting their imagery and limiting distribution, the landscape photographers not only exerted power over viewership (including views taken by their employee-photographers), they also commoditized the West by placing a price on visual consumption. The form this consumption took was generally through the viewer of a stereoscope.

Stereoview historians have estimated that over five million stereoscopic views were made and sold in America during the second half of the nineteenth century.¹⁵ Made for educational and entertainment use, these double-views, which used a viewer to create the illusion of three-dimensional space, drew from a range of subjects, including the American West. Rosalind Krauss has likened the phenomenological stereoscopic experience to that of looking at cinema: “Both involve the isolation of the viewer with an image from which

¹² See Justin Hughes, 335.

¹³ Martin A. Berger, “Overexposed: Whiteness and the Landscape Photograph of Carleton Watkins,” *Oxford Art Journal* 26, no. 1 (2003): 3; discussing Abigail Solomon-Godau’s arguments from her books, *Photography at the Dock*.

¹⁴ Roland Barthes, *Camera Lucida: Reflections on Photography* (New York: Hill & Wang, 1980), 5.

¹⁵ William Culp Darrah, *Stereoviews: A History of Stereographs in American and Their Collection* (Gettysburg, Penn: Time and News Pub, 1964) 91, quoted in Megan K. Friedel and Terry Toedtemeier, “Picturing Progress: Carleton Watkin’s 1867 Stereoviews of the Columbia River Gorge,” *Oregon Historical Quarterly* 109, no. 3 (Fall 2008), 392 (footnote 10).

surrounding interference is masked out. In both, the image transports the viewer optically ... In both, the pleasure derives from the experience of the simulacrum.”¹⁶ Oliver Wendell Holmes, Sr. would describe looking through a stereoscope as a type of “dream-like exaltation, in which we seem to leave the body behind us and sail away into one strange scene after another, like disembodied spirits.”¹⁷ Through the stereoscope, middle-class America not only viewed images of the West from the comfort of their own homes, they asserted dominance through the technology of the prevailing culture (their own). The images testified, theoretically, of the power of the conquerors and their machines, which domesticated the landscape view and transformed the image of the West into a consumable. Roland Barthes alluded to this intersection of commodity, power, and ownership in *Camera Lucida*: “Law has expressed it in its way,” Roland Barthes stated, “to whom does the photograph belong? Is landscape itself only a kind of loan made by the owner of the terrain? Countless cases, apparently, have expressed this uncertainty in a society for which being was based on having. Photography transformed subject into object.”¹⁸

The stereoscopic views of the West became object-commodities to be possessed and enjoyed by American viewers who vicariously participated in the taming of the West. The photographic image functioned as proof of a broader physical and psychological ownership. Focusing on western landscape images at the turn of the twentieth century, Steven Hoelscher remarked, “as part of a more general Victorian ‘search for order’ during a period of radical social and economic unrest, photographic views refracted an ideology of human control over nature in their creation of a new, middle-class, postfrontier space.”¹⁹ The fixed and visible nature of these images related not only to the requirements of American intellectual property law, but also the concept of hierarchical observation. “Disciplinary power,” Michel Foucault wrote in his landmark *Discipline and Punish*, “is exercised through invisibility; at the same time it imposes on those whom it subjects a principle of compulsory visibility. In discipline, it is the

¹⁶ Rosalind Krauss, “Photography’s Discursive Spaces: Landscape/View,” *Art Journal* 42, No. 4 (Winter 1982), 314.

¹⁷ *Ibid.*, citing Oliver Wendell Holmes, “Sun-Painting and Sun-Sculpture,” *Atlantic Monthly* VIII (July 1861), 14-15.

¹⁸ Barthes, 13.

¹⁹ Hoelscher, 549.

subjects who have to be seen. Their visibility assures the hold of the power that is exercised over them.”²⁰

Copyright law played a strong role in the exercise of that power. Copyright suggests intellectual ownership of a view, and registering a copyright brings that view within the legal structure of the prevailing social order. Even the photographer’s presence is diminished in the face of the institutional structure. In the words of Rosalind Krauss, “authorship is characteristically made a function of publication, with copyright held by the various companies, e.g., © Keystone Views ... the institution of the view does not claim the imaginative projection of an author so much as the legal protection of property in the form of the copyright.”²¹ Thus, the copyright was more than a commercial venture, it was a sign of institutionalization: Capitalization had come to claim the West.

Reaching the Summit: Pike’s Peak

The work of William Henry Jackson provides a strong case study of these intersecting principles of commodity and power. Jackson imparted a robust imprint on western American history, having first worked as a photographer in Nebraska in the 1860s before joining the Hayden expeditions to Colorado in the 1870s. Later, Jackson settled in Denver during the last two decades of the nineteenth century, where he produced countless images under the name W.H. Jackson Photographic & Publishing Company. Even after he joined the Detroit Publishing Company in 1897, bringing with him a staggering 10,000 photographic negatives, Jackson still continued to copyright images related to the Colorado area, presumably to reproduce for the mass market.

While the sheer volume of Jackson’s output places him squarely within what might be dubbed the ‘Photo Rush’ of the late 1800s, a closer look at some of his individual copyrighted photographs reveals important trends within the commercial domain. Registered under both the W.H. Jackson Photographic Company and the Detroit Publishing Company, one Colorado view in particular arises repeatedly in the copyright records at the turn of the twentieth century, that of Pikes Peak (Fig. 2).²²

²⁰ Michel Foucault, *Discipline and Punish: The Birth of the Prison*, trans. Alan Sheridan (New York: Vintage Books, 1995), 187.

²¹ Krauss, 314-315.

²² During this era, the mountain was referred to as “Pike’s Peak”, named for nineteenth-century explorer Zebulon Pike, Jr. The apostrophe has since been dropped.



Fig. 2. William Henry Jackson. *Garden of the Gods and Pike's Peak*, ca. 1870.

Significantly, Jackson wasn't the only photographer to register views of the 14,115-foot mountain, a symbol for the Colorado Gold Rush of the late 1850s. Interestingly, however, despite the gold rush slogan, "Pike's Peak or Bust," gold wasn't actually discovered in the Pikes Peak area until the 1890s, at Cripple Creek, and it wasn't until that later period that images of the mountain began populating U.S. copyright records. Between 1895 and 1905, 58 photographs of Pikes Peak were officially copyrighted by 26 different individuals and photographic companies, who hailed from locations ranging from Colorado to Pennsylvania, New York, New Jersey, and Massachusetts. To put these statistics into perspective, since 1978, only two photographs of Pikes Peak appear in the U.S. Copyright records (registered in 2003 and 2013). At the turn of the twentieth century, when registration burdens were considerably greater than under current law, the question should be raised: Why go to the trouble of registering such similar views of the same site? During an era of vastly limited technology, the average person could not readily produce a copy of a photograph. Clearly, registrants sought to limit commercial copying, so that they could profit from the reproduction of their works on the market (Fig. 3). But yet, the sharp decline in photographic copyright registrations from the early to the late twentieth century related to Pikes Peak suggests that the mountain does not necessarily have mass aesthetic or picturesque appeal in its own right.

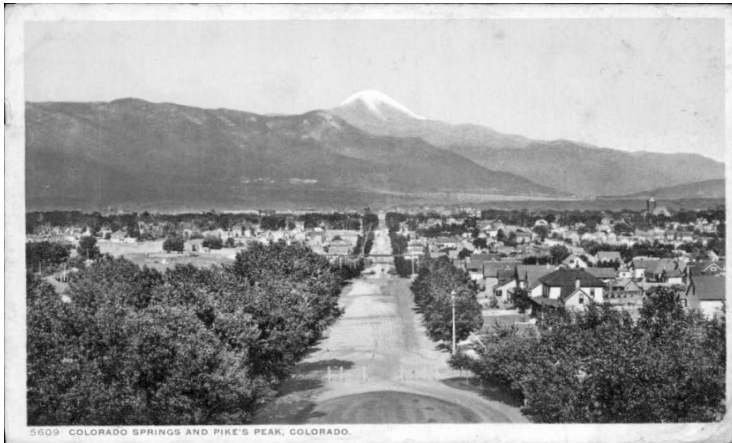


Fig. 3. Postcard of Pike's Peak, produced by the Detroit Publishing Co., c. 1910. Collection of the author.

While Pikes Peak today, sitting in Peak Park, has been deemed a national landmark, our intellectual and psychological value of the mountain has changed. After the West was claimed, tamed, and assimilated into American culture, the need to assert intellectual control over the landmarks of the West diminished. Today, Pikes Peak is a popular tourist site, having become absorbed into the canon of leisure and recreation. But a century ago, Pikes Peak was a crowning example of the need to assert psychological, intellectual, and legal rights over the American landscape, as photographers—and even their audience, claimed and appropriated the landscape as a form of Manifest Destiny and capitalistic fervor.

By the turn of the twentieth century, after the West had been tamed, the economic incentive for producing images lessened. Photographer H.H. Bennett, a contemporary of William Henry Jackson, wrote to a friend in 1899, “My advice to the young would be not to learn photography as a means of gaining a livelihood ... competition is so keen and prices for pictures so low that there is but very little profit in the business.”²³ In February of the following year, Eastman Kodak introduced the Brownie, a mass-market camera that revolutionized amateur photography with the famous slogan, “You push the button, we do the rest.” While Brownie-toting tourists wouldn’t replace the

²³ Cited by Hoelscher, 550.

great photographer–adventurers of the 1870s and 1880s with their large-format cameras and sublime views of the western frontier, times were changing. In the words of W. Miles, G. Cronon, and J. Gitlin, “As the frontier recedes, the wilderness ceases to be either an opportunity for progress or an occasion for terror. Instead, it becomes scenery.”²⁴ Copyrighted photographic views still remained big business, but the incentive had changed. Postcards, decorative prints, and travel ephemera now stood as a reminder of the dominance of the prevailing culture. The West was no longer wild, having been charted, documented, cataloged, and copyrighted into submission.

Bibliography

Barthes, Roland. *Camera Lucida: Reflections on Photography*. New York: Hill & Wang, 1980.

Berger, Martin. “Overexposed: Whiteness and the Landscape Photograph of Carleton Watkins,” *Oxford Art Journal* 26, no. 1 (2003): 3-23.

Bracha, Oren. “The Ideology of Authorship Revisited: Authors, Markets, and Liberal Values in Early American Copyright,” *The Yale Law Journal* 118, no. 2 (2008): 186-271.

Byellin, Jeremy. “Legal Research: Thoughtful Articles About Legal Research and Solutions,” *Legal Solutions Blog*. 31 May 2013. Retrieved March 10, 2014, from <http://blog.legalsolutions.thomsonreuters.com/legal-research/today-in-1790-the-first-federal-copyright-act-is-signed-into-law/>.

Catalogue of Title Entries of Books and Other Articles Entered into the Office of the Librarian of Congress at Washington Under the Copyright Law, nos. 131-184 (Washington: Government Printing Office, 1894). Retrieved February 15, 2014, from <https://archive.org/details/catalogoftitleen13018libr>.

²⁴ W. Miles, G. Cronon, and J. Gitlin, “Becoming West: Toward a New Meaning for Western History,” in *Under an Open Sky: Rethinking America’s Western Past*, edited by W. Cronon, G. Miles, and J. Gitlin, (New York: W.W. Norton: 1992) 81.

Catalogue of Title Entries of Books and Other Articles Entered into the Office of the Librarian of Congress at Washington Under the Copyright Law, vols. 22-25 (Washington: Government Printing Office, 1900). Retrieved February 15, 2014, from <https://archive.org/details/catalogoftitlee190124libr>.

W. Cronon, G. Miles, and J. Gitlin. "Becoming West: Toward a New Meaning for Western History." In *Under an Open Sky: Rethinking America's Western Past*. Edited by W. Cronon, G. Miles, and J. Gitlin. New York: W.W. Norton, 1992.

Farley, Christine Haight. "The Lingering Effects of Copyright's Responses to the Invention of Photography," *University of Pittsburgh Law Review* 65 (2005): 385-456.

Foucault, Michel. *Discipline and Punish: The Birth of the Prison*. Translated by Alan Sheridan. New York: Vintage Books, 1995.

_____. *The Order of Things: An Archaeology of the Human Sciences*. New York: Vintage Books, 1970.

Friedel, Megan K. and Terry Toedtemeier. "Picturing Progress: Carleton Watkin's 1867 Stereoviews of the Columbia River Gorge," *Oregon Historical Quarterly* 109, no. 3 (Fall 2008): 388-411.

Hoelscher, Steven. "The Photographic Construction of Tourist Space in Victorian America," *Geographical Review* 88 (Oct. 1988): 548-570.

Hughes, Justin. "The Photographer's Copyright—Photograph as Art, Photograph as Database," *Harvard Journal of Law & Technology* 25, no. 2, (2012): 327-416.

Krauss, Rosalind. "Photography's Discursive Spaces: Landscape/View." *Art Journal* 42, No. 4 (Winter 1982): 311-319.

Trachtenberg, Alan. *The Incorporation of America*. New York: Hill and Wang, 1982.

Sociopolitical Influences on the Creation of the Ballet *Giselle*

Rose Hutchins

Utah Valley University

Abstract

This research explores the relationship between the sociopolitical turmoil among French citizens during the July Monarchy (1830–1848) and the original production of the Romantic ballet Giselle (1841). Often considered the quintessential Romantic ballet, Giselle has traditionally been interpreted by focusing on typical characteristics of Romanticism, such as quasi-medieval settings, love of the fantastic, longing for unattainable love, and emotionally driven plotlines. However, failing to also consider the sociopolitical milieu of the time of Giselle's premiere gives a limited picture of the meaning within the ballet. A critical analysis of Giselle from a New Historicism perspective provides a more complete understanding of this Romantic ballet by illuminating underlying social and political tensions among the French citizens during the reign of the July Monarchy. The use of New Historicism, a frame of analysis that places historical events within their cultural context, assisted in drawing connections between Giselle and surrounding events of Paris, France, during the mid-1800s. The French sociopolitical environment was turbulent in the years leading up to and following Giselle's premiere because of conflicts between the two main political factions of the July Monarchy: the parti de résistance and the parti du mouvement. The results of this research

demonstrate that the ballet Giselle reflects this political turmoil, both in its dancing and in its plotline.

Giselle (1841), often considered the quintessential Romantic ballet, has traditionally been interpreted by focusing on typical characteristics of Romanticism. Common characteristics of this era include quasi-medieval settings, love of the fantastic, longing for unattainable love, and emotionally driven plotlines. However, failing to also consider the sociopolitical milieu of the time of *Giselle*'s premiere gives a limited picture of the meaning within the ballet.

Giselle was created and premiered in France during the reign of the July Monarchy (1830–1848), which came to power by way of the July Revolution (1830). Two political parties, the conservative *parti de résistance* and the liberal *parti du mouvement*, led this revolution. While both of these parties possessed a common goal to replace King Charles X of the Bourbon Restoration (1757–1836) with King Louis-Philippe I (1773–1850), they had different long-term objectives. The *parti de résistance*, which was primarily made up of the aristocrats and the wealthy upper-middle class referred to as the *bourgeoisie*, simply viewed the revolution as a change of leadership and therefore a shift of power and status in their favor (Collingham and Alexander 24, 31). However, the *parti du mouvement*, which mainly consisted of the working class and the rising generation, had a greater change in mind when they conspired with the *parti de résistance* to overthrow the previous regime. The liberal *parti du mouvement* was anxious for political, social, and economic change. The new July Monarchy did not meet these expectations, however, and as the years progressed the *parti du mouvement* started to call for reforms such as universal suffrage, changes to the electoral system, and work for the unemployed (Collingham and Alexander 389).

Because the *parti de résistance* and the *parti du mouvement* never came to a clear agreement about how the country would transition after the revolution, there remained a constant sense of tension among the French people. The upper class wanted to maintain control, while the lower class sought to create equality. This political turmoil is reflected in the ballet *Giselle*, both in its plot and through its choreography. A critical analysis of *Giselle* from a New Historicism perspective provides a more complete understanding of this Romantic ballet by illuminating underlying social and political tensions among the French citizens during the reign of the July Monarchy.

A review of source material and a critical analysis of *Giselle* will supply answers to the following questions:

1. What is a New Historicism perspective, and how does it benefit this research?
2. What was the sociopolitical environment of Paris, France, in the years leading up to *Giselle*'s premiere?
3. How does a critical analysis of *Giselle* reflect the sociopolitical climate in France during the mid-nineteenth century?

New Historicism

Traditionally, Romantic ballets like *Giselle* have been analyzed based on their reflection of social outlooks and philosophies, with the Feminist perspective being perhaps the most common frame of analysis used to examine this particular ballet. Among others, dance scholars Evan Alderson ("Ballet as Ideology" 294-302) and Susan Leigh Foster (*Choreography & Narrative* 198, 243-251) have researched and written from this viewpoint, which frequently argues that *Giselle* is a cautionary tale used as a tool to subjugate women and to promote male dominance. Another approach to critically analyzing *Giselle* is to use a Structuralism frame of reference, examining the binary opposition present throughout the ballet, including themes such as the common folk versus the nobility, the natural versus the supernatural, and the wilis' bitterness versus Giselle's forgiveness (Foster 247). Yet another way of analyzing the ballet is through a Psychoanalytic perspective, exploring the psychology of the mad scene, or the overarching themes of "abjection, love, and melancholy ... woven into *Giselle*" (Brumer 110). While these and other traditional approaches to researching Romantic ballets provide interesting insights, they miss an important part of the historical significance lying within the ballet *Giselle*. The application of a New Historicism perspective lends additional insights by considering the social and political milieu of Paris leading up to the premiere of the ballet in 1841.

New Historicism is a relatively new frame of analysis, or perspective used to form an argument, which developed among academics in the late twentieth century to provide a more complete look at individual events by placing them within their greater historical context. This way of analyzing and interpreting an event acknowledges that a given phenomenon both influences and is influenced by its surrounding social and political culture (Tyson 284). Therefore, to truly understand the ballet *Giselle*, it is necessary to also understand the social and political environment in which it was created and first performed. By looking at the ballet in this way, one can come to understand the political and social undertones that may have influenced both its conception and its reception.

Historical Context

Giselle premiered at the Paris Opéra on June 28, 1841, during the reign of King Louis-Philippe I, the selected ruler of the July Monarchy. Louis-Philippe was a natural choice for this new regime given his upbringing and personal history, which enabled him to relate to both the conservative and the liberal perspectives. Although he came from a line of nobility, Louis-Philippe was raised with semi-republican principles (Collingham and Alexander 95). Living in poverty and exile for many years after escaping the Reign of Terror (1793–1794), a frenzied period during the French Revolution (1789–1799) when revolutionaries indiscriminately executed the aristocracy by guillotine, Louis-Philippe experienced a difficult life and is believed to have flirted with liberal philosophies for a time (Collingham and Alexander 3, 95-96; Homans 143).

To demonstrate his connection and devotion to the French people, Louis-Philippe called himself the “King of the French” rather than the “King of France.” Early in his reign, Louis-Philippe walked freely and unprotected among his people, holding an umbrella in place of a scepter. He came to be known as the “Citizen King,” but unfortunately this sentiment did not last among the people. Although Louis-Philippe refused to declare an association with either party, it quickly became clear that he held the same conservative views as the members of the *parti de résistance*, who made up the majority of his cabinet. Still, Louis-Philippe made an effort to satisfy both sides, holding to his philosophy of ruling by the *juste milieu*, or the golden mean (Collingham and Alexander 108-109; Homans 143-144). His efforts at compromise, however, did not please either party and led to persistent criticism that Louis-Philippe was a weak leader (Collingham and Alexander 97).

Members of the *parti du mouvement* called him deceitful, saying that Louis-Philippe willfully broke the Charter he swore to honor, which was drawn up by the new regime to outline the organization of the government and the rights and privileges of its citizens. The conservative *parti de résistance*, however, did not see the king in the same light. Guizot, one of Louis-Philippe’s right-hand men, said, “He has been called false, but I have never found him so” (qtd. in Collingham and Alexander 96). This division in opinion was likely the result of ambiguity within the Charter, which implied that the Chamber of Deputies would possess increased power in government but did not formally provide them with these rights. Substantial changes made in the Charter included removing the state religion, instituting freedom of the press, and lowering the voting age (Collingham and Alexander 27-

28, 70). Unfortunately for the *parti du mouvement*, a tax placed on the right to vote limited the common people's voice in government decisions (Collingham and Alexander 70-71). This imbalance resulted in a false sense of security for the government and increased tension among the *parti du mouvement*. The existing political inequality was compounded by Louis-Philippe's disregard for any criticism he received from those he considered to be uneducated. This attitude would eventually be Louis-Philippe's undoing (Collingham and Alexander 97), as is evident by the numerous assassination attempts that he faced during his reign. These attempts on the king's life were carried out by radical liberal splinter groups that subscribed to the republican declaration, "Those whom we have put in power have betrayed us. Let us arm ourselves!" (qtd. in Collingham and Alexander 35).

In the midst of this social and political turmoil, there were some who distanced themselves from politics altogether. This group included many of the artists and writers of Paris. While those artists with political interests generally leaned toward the liberal *parti du mouvement* (Collingham and Alexander 270), most of the creative minds of this era were disillusioned with society and chose to disassociate themselves from either party, subscribing to the Counter-Enlightenment point of view. This mentality was a response to the logic-driven Age of Enlightenment that preceded the Romantic era. Unhappy with the social upheaval of the many successive revolutions in France and the callous attitude of the Industrial Revolution, which these artists and philosophers attributed to the Age of Enlightenment, they yearned for what they imagined to have been a better past. Thus emerged the common use of quasi-medieval settings for Romantic ballets and the supernatural themes that allowed people to escape reality (Homans 157-158, 165-166).

Théophile Gautier (1811-1872), the primary writer of *Giselle*, belonged to this group of thinkers. Gautier and his fellow artists expressed their disappointment in the July Monarchy and the "crass materialism" (Homans 153) it encouraged. At the same time, however, they abhorred the idea of yet another revolution and more bloodshed. Resigned to his country's current state of affairs, Gautier sought to escape France's "fatal descent into bourgeois mediocrity" (Homans 165) through artistic beauty and the exploration of the supernatural. Although he claimed that he had no interest in politics (Collingham and Alexander 274), Gautier's personal feelings about society and the surrounding political unrest, which peaked around 1840, certainly must have informed his creation of *Giselle*.

Gautier wrote the story for the ballet, which he originally titled *Giselle, ou Les Wilis*, loosely based on the writings of two of his contemporaries and friends, Heinrich Heine and Victor Hugo. He worked with the famous librettist Jules-Henri Vernoy de Saint-Georges (1799–1875), who helped him to shape the story so that it would translate to the stage. Saint-Georges is primarily responsible for working with Gautier to adapt the ballet's first act to give the storyline more substance and to better set up the second act (Smith, "What Killed Giselle?" 75-76). The revised version of the first act of *Giselle* focuses on the separation of class, reflecting Saint-Georges's nostalgia for the ways of the previous century and his affinity for high society. Although not an aristocrat by birth, Saint-Georges was welcomed and respected among the wealthy, as he dressed and acted the part of a gentleman (Curtiss 172-173).

Saint-Georges's perspective presents a stark contrast to that of Jules Perrot (1810–1892), the primary choreographer for *Giselle*. Perrot was so inspired by the potential of the ballet that he agreed to choreograph the majority of *Giselle*, even though sole credit for the choreography would go to his superior Jean Coralli (Guest, *The Romantic Ballet in Paris* 345-348; Guest, *Jules Perrot* 74, 350). Although his political affiliation is unclear, Perrot likely favored the *parti du mouvement*, having grown up as a member of the working class. This conclusion can be drawn based on his family's background as silk workers in Lyon, a group known for their uprising against the July Monarchy in 1831 (Guest, *Jules Perrot* 20; Homans 148, 166), as well as Perrot's personal involvement in a later revolution in Milan, Italy (Guest, *Jules Perrot* 219).

Understanding the political and social biases held by Gautier, Saint-Georges, and Perrot is vital to analyzing *Giselle* from a New Historicism perspective, as their opinions surely must have played a role in its creation—whether consciously or not. Each contributor must have brought a unique perspective to the formation of *Giselle*'s plot and movement. With Gautier, a true Romantic, Saint-Georges, an old-fashioned man with aristocratic preferences, and Perrot, a working-class dancer and choreographer, this group appears to represent each major body of the time period. It is likely that the complexity of *Giselle*'s social and political references are a result of these diverse social and political viewpoints coming together to shape the ballet.

As important as it is to recognize the potential biases and perspectives of the creators of the ballet, it is equally important to recognize the mindset of the intended audience. The *bourgeoisie*, society's wealthy, self-made men who had at last attained nearly equal status and power as the aristocrats, made up the majority of the

audience (Homans 144). It was necessary that the performances appeal to their viewpoint in order to be profitable. Even more importantly, however, the opera house was obligated to promote the government's agenda. Although Dr. Louis Véron (1798–1867) privately owned the Paris Opéra, it still received supplemental state funding (Foster 209). For this reason, Véron, the epitome of a bourgeois gentleman (Guest, *Jules Perrot*, 20; Homans 144), had no intention of promoting any performance that would be incompatible with the current regime. Understanding the government's use of the opera house as a tool to give the illusion of peace and prosperity in Paris, Véron said, "The success and profit of the Opéra must give the lie to the riots" (qtd. in Collingham and Alexander 284). In this way, the Paris Opéra provided a comforting façade to the members of the *parti de résistance* who enjoyed their current situation and feared the death and turmoil of yet another revolution.

Even while placating the monarchy, political statements could and would still be made through the arts. Artistic expression addressing discontent generally precedes large-scale physical protest because these statements are subtler and therefore less hazardous to the activist (Ringer and Locke 1). The dancing nuns scene from the opera *Robert le Diable*, premiering at the Paris Opéra in 1831, is an example of such a statement during the Romantic era. In this famous scene, Robert, the opera's protagonist, is accosted by "a group of ghostly nuns [who are] bent on his destruction" (Homans 147). Although there were many different interpretations of *Robert le Diable*'s meaning, there was an overwhelming consensus among the audience that the performance pointed to the political tensions present early in the July Monarchy (Homans 149-150). Political statements were rampant in other art forms as well. Victor Hugo claimed that Romanticism, which focused on human emotion, was "liberalism in literature" (Collingham and Alexander 270). Operas promoted the government's point of view by incorporating storylines that cautioned citizens against rebellion (Ringer and Locke 54-55). At the same time, popular songs were written and distributed to rally republican supporters (Ringer and Locke 55). These examples support the argument that *Giselle* also presents political anxieties and frustrations within its plot and choreography.

Critical Analysis

To understand the political implications in the ballet *Giselle*, one must examine both the plot and the actual movement. In building this argument, it is necessary to acknowledge that the version of *Giselle* performed today has been modified throughout the years and, as a

result, is not completely accurate to the original performance in 1841. Every version of *Giselle* in existence today is derived from the Petipa rendition, which is based on the original choreography but has been through a number of modifications (Guest, *Jules Perrot* 350). With this caveat disclosed, the essence of the dancing and the story has remained constant, and with some written documentation about the original ballet (Gautier 52-58; Smith, "The Earliest *Giselle*?" 29-47), many of the missing pieces can be imagined.

The ballet *Giselle* exemplifies the qualities of the Romantic era that appealed to those of the Counter-Enlightenment mentality. *Giselle* is placed in a vaguely German village along the Rhine in a quasi-medieval setting, hearkening back to the days of old. The story centers on two main themes that were both popular during the Romantic era: the supernatural and unattainable love.

The ballet follows the story of a young peasant girl named Giselle who loves to dance but has a weak heart. Her mother repeatedly warns her that if she continues to dance, it will strain her heart to the point that she will die and become a *wili*, or a spirit, believed to haunt the nearby forests. Giselle disregards her mother's advice and continues to dance, performing lively sequences full of jumping and quick footwork with her friends and with Loys, a mysterious visitor with whom she has fallen in love. In the beginning of the ballet, Loys declares his love for Giselle, raising his right hand to the sky with his first two fingers extended, even though he knows that he can never marry her. In reality, he is only masquerading as a peasant; he is in fact Duke Albrecht of Silesia, betrothed to a noblewoman named Bathilde. Not long after Giselle and Albrecht dance together, a royal hunting party visits the village to rest, entering the stage in a regal, processional manner. By chance, Bathilde and Giselle meet, unaware that they are both engaged to the same man. When Giselle discovers Albrecht's betrayal, she is overcome with grief and goes mad. She pushes her way between Bathilde and Albrecht, breaking them apart, then runs around the stage in a daze, ultimately collapsing in Albrecht's arms and dying of a broken heart.¹

In the second act, Myrtha, Queen of the Wilis, initiates Giselle into the wilis' sisterhood of young women who have each died as the

¹ There is some argument as to whether Giselle died of a broken heart or committed suicide in the premiere of the ballet. However, Marian Smith makes a compelling argument in her article "What Killed Giselle?" that Giselle died of a broken heart in the original performance.

result of an unfaithful lover. Every night the wilis rise from their graves, forcing any man who crosses their path to dance until he dies. That night, Albrecht comes to Giselle's grave to mourn her loss. Myrtha commands Giselle to lure Albrecht into the midst of the wilis so that they can dance him to death. Giselle, who is still in love with Albrecht, initially refuses and attempts to protect him, but she is not as powerful as Myrtha and the other wilis. Reluctantly, Giselle walks to center stage following Myrtha, as if pulled by an unseen force. She begins a slow, mournful dance, extending her leg in an impressively high and controlled *développé*, gazing at the floor the entire time with regret. Albrecht joins her in a somber *pas de deux*, or dance for two, full of suspended movements and an indirect focus that combine to give a floating, otherworldly feeling to the dance. At first, Albrecht appears calm and strong as he partners² Giselle and later performs challenging jumps that move across the stage. But exhaustion begins to show by the end of his *variation*, or solo dance, when he collapses to the floor rather than landing the final *double tour* in a noble pose. At this point, Albrecht is completely exhausted and Giselle pleads with Myrtha to have mercy. When Myrtha refuses, Giselle goes to Albrecht, as if to reassure him that all will be well, and then dances a sprightly variation in his stead. Her movements are buoyant as she jumps back and forth across the stage. Near the end of her dance Giselle takes a moment to breathe life into Albrecht, gently hovering over him with her arms outstretched, gracefully fanning the air over his body. As soon as he has recovered some strength, the wilis force Albrecht to dance again, performing repetitive jumps across the stage. Each time he tries to stop dancing, a wili blocks his path and demands, with an accusing point of her finger, for him to continue. Ultimately, Albrecht collapses again but is rescued from the wilis' grasp by the break of dawn. Because of the love, mercy, and forgiveness that Giselle has shown, she returns to her grave to rest in peace, but not before she first gestures for Albrecht to go to his fiancée Bathilde, who is waiting for him.³

While at first glance this ballet might seem like a simple story of unattainable love, it can be argued that there is deeper meaning given the cultural context of its premiere. The first act of the ballet deals with the separation of class and the potential problems with integrating

² Partner (v): A term used by ballet dancers to describe the support and assistance a male dancer provides to his female partner to enhance her existing abilities.

³ In the original production, Albrecht and Bathilde were reunited at the end of the ballet, but this part of the story has since been removed. In current versions, the ballet ends with Albrecht left alone on stage to deal with his grief (Gautier 58; Brumer 108-109).

classes, an issue France was still dealing with even after the most recent revolution. The choreography and the costuming work together to illustrate this class distinction. The peasants, wearing simple earth-tone costumes, perform energetic dances at a social gathering held to celebrate the harvest. The buoyant style, as well as the setting of the dance, is characteristic of the lively, jumping *ballo* dances associated with the common folk (Sorell 43, 45). In contrast, the lords and ladies, dressed in elaborate, vibrant costumes, move about the stage in a slow and controlled manner with their chests thrust out and their chins lifted, reminiscent of the processional *basso* dances of the nobility in olden days (Sorell 43, 45). It is interesting to note that in this ballet, the nobles never actually dance. Instead, as a form of entertainment, they sit and observe the peasants dancing, just as the upper class of the Romantic era came to the Paris Opéra to watch the lower class perform *Giselle*.

The demonstration of class distinction, and the drama that ensues when the prince is found out, points to the issues among the French people at that time. The *parti du mouvement* was lobbying for equality and a socialized system. The radicals of this movement called for communism,⁴ believing that “inequality [was] the source of evil,” and that equality could only be achieved through both social and political change (Collingham and Alexander 372). The pretended equality of the July Monarchy was certainly on the mind of at least one newspaper critic while watching the original production of *Giselle*. His satirical review published in *La Revue et Gazette Musicale* stated:

Giselle dies for a reason other than dancing too much: what kills her is her chagrin upon learning suddenly that Loys is a disguised prince; that someone she believed to be her equal is actually Duke Albrecht of Silesia! Doesn't she know that kings can marry shepherdesses? ... one should not raise a child with such an incomplete education! (qtd. in Smith, “What Killed Giselle?” 70)

This criticism points to the *parti du mouvement*'s accusation that Louis-Philippe was a hypocrite, presenting himself as the “Citizen

⁴ Not to be confused with the idea of Communism that became prominent in the 20th century, the French call for communism referred to a Utopian concept of dividing France into communes with citizens of equal status working and living together (Collingham and Alexander 372-373).

King.” Although Louis-Philippe indicated that he was one of the people, there was still clearly an insurmountable gap between the working class and those who were ruling the country. Note the writer’s sarcasm when he suggests that a king can marry a shepherdess. A king would never marry a peasant, nor would a peasant have an education.

It does not seem coincidental that the deceptive Albrecht is a duke, just as Louis-Philippe was the Duc d’Orléans before ascending the throne. In the eyes of the *parti du mouvement*, Louis-Philippe was falsely masquerading as the “Citizen King” in the same way that Albrecht disguised himself as a peasant. Even though Albrecht is dressed plainly in Act I, his true identity is still evident in his movement; his body language is stately, confident, and majestic. Similarly, Louis-Philippe would never truly be one of the people. Although a prince, it is interesting to see how Albrecht’s confident body language shifts when Giselle, who could symbolically represent the *parti du mouvement*, discovers his betrayal. When she confronts him, he appears weak and indecisive, standing unresponsive to one side, head turned away, refusing to acknowledge either Giselle or his fiancée, Bathilde, who could easily represent the *parti de résistance*. By avoiding eye contact with Giselle and Bathilde, Albrecht forces these two parties to settle their differences on their own. This points to the accusation that Louis-Philippe was an incompetent ruler who would not take command. Giselle, the weaker party, and the character with the heart condition, demonstrates her weakness through movement. She crouches, holding her head as she tries to make sense of the situation; she then wanders around the stage in a disoriented state, eventually breaking into a frantic run before ultimately collapsing to her death. This demonstrates both the *parti du mouvement*’s weakness and the manic behavior of the revolutionaries. Bathilde, the more powerful party, stands regally, looking down at Giselle. Bathilde seems barely disturbed by the chaos as she watches her rival’s descent, standing with poised body language to show her place as a member of the aristocracy.

Act II shows the cold and calculating wilis. Their stiff, mechanical movements and the repetitive sequences they perform show their unyielding nature and unrelenting mentality. Likely representing the radical splinter groups of the *parti du mouvement*, the wilis, who are dressed identically in white, move in complete synchronization and unison. This brings to mind the radicals’ goal of socialism. The wilis’ queen, Myrtha, standing with a haughty posture and using forceful gestures, is reminiscent of the radical captains who spouted ideas of equality but jealously guarded their positions as leaders of the movement (Collingham and Alexander 383). Members of these radical groups attempted to assassinate the king. Their attempts are brought to

mind as the wilis gesture that they will not have mercy on the disloyal Albrecht, and that Giselle, who represents the liberal party, must join them in dancing him to death. Albrecht is powerless to the wilis and their demands. He shows this when he kneels to their queen, begging for his life, then again through his frantic and repetitive *entrechat six* when he is forced to continue dancing, and most obviously in his collapse to the floor at the end of both his variation and the finale. Albrecht's physical weakness points to Louis-Philippe's weakness in running his country and the lack of control he possessed over the radical groups, in spite of his best efforts. Albrecht's act of physically kneeling and begging for his life brings to mind the criticism leveled at the July Monarchy by politician Saint-Marc Girardin, who described it as "a government which does not govern, but humbly begs to obey" (qtd. in Collingham and Alexander 35-36). When at last the wilis are defeated, it is not through the strength or power of any of the leading characters. Instead, the wilis simply fade away with the dawn (Homans 168), much as the *parti de résistance* seemed to hope the troubles plaguing the monarchy would somehow disappear with time. As the wilis fade away, so does Giselle, gesturing to Albrecht to return to his fiancée Bathilde, or the primary political party. The original version of the ballet ends with Albrecht rescued from the wilis, forgiven by both Giselle and Bathilde, and reunited with his own class. Thus, the wealthy audience members feel that they have a happy ending, but in reality their problems have not truly been resolved. After all, there is nothing to prevent the wilis from retaliating on some future night if Albrecht ever ventures into the woods again.

Conclusion

This analysis suggests that the ballet *Giselle* is an allegory that brings attention to the political tension and conflict in France during the reign of the July Monarchy. It speaks to the anxieties and the frustrations of the two political factions, the *parti de résistance* and the *parti du mouvement*. The ballet touches on the issue of class, highlights Louis-Philippe's shortcomings as a leader, and demonstrates the growing threat of the radical groups within the *parti du mouvement*. To promote the government's agenda, the ballet's plot encourages peace and loyalty, praising Giselle's forgiveness and support in contrast to Myrtha's vengeful retaliation. Finally, the ballet suggests the monarchy's wish that the aristocracy should be allowed to continue on their way with minimal consequences, in spite of the *parti du mouvement's* accusations of betrayal.

Whether these messages were consciously or subconsciously created, it is clear from this analysis that the creation of the ballet *Giselle* was influenced by its surrounding political and social culture. According to Gautier, *Giselle* was extremely successful (Gautier 58-59). This may have been because the audience recognized the political statements within the plot and movement of the ballet, or simply because *Giselle* appealed to the romantic sensibilities of the time. Regardless of the creators' intent or the public's reception of the ballet, an analysis of *Giselle* from a New Historicism perspective demonstrates that it does indeed mirror the social and political tensions among the French people, reflecting the culture of the time and serving as a vehicle for political expression.

Acknowledgments

I sincerely thank Angela Banchero-Kelleher for mentoring me through the process of researching, presenting, and publishing this work. Many thanks to my family members and friends who took the time to review my work and provide invaluable feedback.

Works Cited

Alderson, Evan. "Ballet as Ideology: *Giselle*, Act II." *Dance Chronicle* 10.3 (1987): 290-304. JSTOR Journals. Web. 17 Sept. 2015.

Brumer, Jody. "Redeeming *Giselle*." *Rethinking the Sylph: New Perspectives on the Romantic Ballet*. Comp. Lynn Garafola. Hanover, NH: Univ. of New England, 1997. 107-19. Print.

Collingham, H. A. C., and R. S. Alexander. *The July Monarchy: A Political History of France, 1830-1848*. London: Longman, 1988. Print.

Curtiss, Mina. "La Jolie Fille De Perthe: I." *Bizet and His World*. New York: Knopf, 1958. 172-84. Print.

Foster, Susan Leigh. *Choreography & Narrative: Ballet's Staging of Story and Desire*. Bloomington: Indiana UP, 1996. Print.

Gautier, Théophile. "Giselle." *The Romantic Ballet*. Trans. Cyril W. Beaumont. London: C.W. Beaumont, 1947. 50-59. Print.

Giselle. Dir. Ross MacGibbon. Perf. Alina Cojocaru, Johan Kobborg, Marianela Nuñez, and Martin Harvey. Opus Arte, 2006. DVD.

Giselle. Dir. Tina Protasoni. Perf. Svetlana Zakharova, Roberto Bolle, Vittorio D'Amato, and Marta Romagna. Arthaus Musik, 2011. DVD.

Guest, Ivor. *Jules Perrot: Master of the Romantic Ballet*. New York: Dance Horizons, 1984. Print.

Guest, Ivor. *The Romantic Ballet in Paris*. Hampshire: Dance, 2008. Print.

Homans, Jennifer. "Romantic Illusions and the Rise of the Ballerina." *Apollo's Angels: A History of Ballet*. New York: Random House, 2010. 135-75. Print.

Ringer, Alexander L., and Ralph P. Locke. *The Early Romantic Era: Between Revolutions, 1789 and 1848*. Englewood Cliffs, NJ: Prentice Hall, 1991. Print.

Smith, Marian. "The Earliest *Giselle*?" A Preliminary Report on a St. Petersburg Manuscript." *Dance Chronicle* 23.1 (2000): 29-48. JSTOR. Web. 12 July 2014.

Smith, Marian. "What Killed *Giselle*?" *Dance Chronicle* 13.1 (1990): 68-81. JSTOR. Web. 12 July 2014.

Sorell, Walter. "Long Awakening." *Dance in Its Time*. Garden City, NY: Anchor/Doubleday, 1981. 3-46. Print.

Tyson, Lois. *Critical Theory Today: A User-friendly Guide*. New York: Garland Pub., 1999. Print.

The Symphony and the Ballet: Select Compositions of Tchaikovsky as an Educational Tool for Music and Ballet

Justine Sheedy-Kramer

Utah Valley University

ABSTRACT

The significant influence of Pyotr Ilyich Tchaikovsky's compositions is readily apparent in both music and ballet. Many of Tchaikovsky's compositions provide strong and unique connections between music and ballet that can be used to improve understanding between students in the study of these two fields. This paper uses a survey, with specific references to Tchaikovsky, to determine how well music and ballet students understand the connections between these fields. As the survey showed that their understanding of these connections is suboptimal, the paper then demonstrates how select compositions of Tchaikovsky can be used as an educational tool in music and ballet to increase students' understanding of these connections and thus also promote cross-field collaboration. This educational tool is developed using a combination of historical perspectives, structural comparisons, and artistic elements all pertaining to Tchaikovsky's symphonies and ballets.

I. INTRODUCTION

Pyotr Ilyich Tchaikovsky's symphonies and ballets have contributed significantly to the fields of music and ballet, and many of his compositions can also be viewed as the prime intersecting point between Romantic music and Classical ballet. Several of these compositions provide strong and unique connections between the two fields and also provide unique opportunities to enhance student comprehension of these connections. It is my goal to determine whether a specific cross-section of compositions could serve as a learning device to showcase the challenges and opportunities for communication and comprehension between music and ballet. Music and ballet students were surveyed for this purpose, and the results were used for this paper to analyze student understanding of the connections between music and ballet. Based on the results of this survey, an educational tool was developed that can be used to increase students' understanding of the connections between music and ballet, and thus also promote cross-field collaboration.

Tchaikovsky's three ballets—*Swan Lake*, *The Sleeping Beauty*, and *The Nutcracker*—are widely recognized by musicians and ballet dancers alike and will serve as part of this educational tool. Foundational parallels are then established using a comparable set of three symphonies: Tchaikovsky's Fourth, Fifth, and Sixth Symphonies. In turn, an effective presentation of basic cross-form elements is formulated via these six compositions. Specific connections are identified through historical perspectives, structural comparisons, and artistic elements. These connections among the six compositions can offer students a stronger understanding of both music and ballet, in addition to providing communication tools for collaborative projects. Although music and ballet are naturally interconnected, students often do not have the opportunity to actively engage in these connections until they reach the professional setting. The educational and artistic application of these select compositions can assist students in improving their comprehension, enhancing their performance artistry, and developing their creative works. By narrowing the scope to a concise reference set, students are presented with an efficient way to study introductory material and explore the challenges and opportunities presented by collaboration in music and ballet.

II. THE SURVEY

To identify initial student comprehension, 79 students in the Departments of Dance and Music at Utah Valley University were surveyed regarding their interest in and perception of their educational

counterparts' art form. Students in the Ballet Technique II–IV and Symphony Band classes participated in this survey.¹ The purpose of this survey was to determine students' comprehension, misunderstandings, and areas of interest. The survey (Appendix: IRB #01387) classified musicians versus dancers, queried the students about their knowledge of Tchaikovsky's compositions, requested identification with selected terms ("Tchaikovsky," "ballet," and "symphony"), and asked what questions or interests the students had regarding music, ballet, and the connections between both fields.

The compositions most familiar to the students surveyed were *The Nutcracker* and *Swan Lake*, with 63% of the students stating that they were familiar with at least one of these two ballets. The Fourth and Fifth Symphonies, as well as the *1812 Overture*, were also recognized by the music students. Interestingly, the music students also listed several other ballets that were not composed by Tchaikovsky, including *The Rite of Spring* and *The Firebird*. In addition, members of both groups identified *Romeo and Juliet* as one of Tchaikovsky's compositions, which could raise interesting comparisons as the familiar ballet score was composed by Sergei Prokofiev (and Tchaikovsky's composition was an overture). Also intriguing was that no music students listed Tchaikovsky's Sixth Symphony and only 16% of ballet students identified *The Sleeping Beauty* as one of Tchaikovsky's compositions. These details can be used to indicate the level of student understanding and to guide the potential application of an educational tool for enhancing student understanding.

In regards to identifying terms, the ballet students seemed to have a very narrow concept of a symphony, with 74% of these students associating the term "symphony" with the performing entity rather than with the musical form. Forty-one percent of the music students made the same association. In addition, only 15% of music students and 8% of the ballet students associated a composer or composition with the term "symphony." These statistics demonstrate that there is considerable scope to enhance ballet students' comprehension of structural form in music.

As demonstrated in Figure 1, the music students stated a variety of questions and interests regarding the connections between music and

¹ Students who had already taken the *Music for Ballet Dancers* course were excluded from the survey as they may have had prior knowledge that could have skewed the results of the survey.

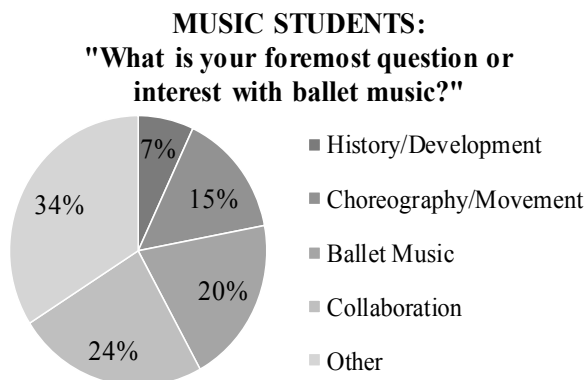


Figure 1: Survey of music students

ballet, including: "Different characteristic(s) with scenes and such" and "I love to listen to it and watch the ballet," as well as "Everything" and "Never really thought about it before." As demonstrated by Figure 2, the ballet students seemed to be most concerned with the relationship between music and ballet through history and development. Questions and interests for the ballet students regarding history and development included: "To learn more about how ballet has transformed from an accompaniment of classical music to becoming the main purpose of a performance, while the music is in the background" and "How did classical dance shape the way that music was written?" as well as "I just want to know more. I recognize the music but don't always know who it's by or what it's from" and "Did any of the music inspire the choreography of main ballets?" Both groups were curious as to how music can assist dancers and support movement. In addition, the ballet students were interested in how to count music and how to apply rhythmic patterns to their dancing or future teaching. Several music students were intrigued by the way dancers interpret music as well as the collaborative possibilities posed by a joint performance. While 24% of the music students were interested in collaborative possibilities, the ballet students did not state any interest in the possibilities for collaboration that these two fields present. A few music students specifically stated that they would be interested in accompanying a ballet performance in the future (and educators could use this interest to enhance student learning and interaction). Approaching both fields using specific compositions that demonstrate key historical and structural connections provides an essential basis with which to interest students in collaborating academically and artistically.

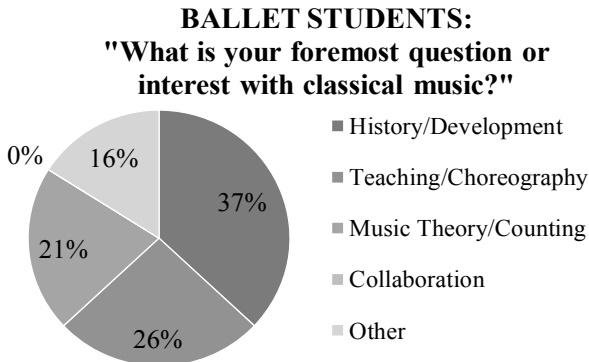


Figure 2: Survey of ballet students

The goal of this survey is to develop an educational tool that can be used to increase comprehension for students in music and ballet. In addition, this comprehension can be applied by students towards the development of their creative works and performance skills. Music and ballet share prime resources that can enable educators to provide thorough and meaningful information to their students. Finding concise yet resourceful materials, while tailoring instruction to student goals and interests, can be a challenge for any educator. In addition, balancing effective and purposeful instruction with time constraints and student comprehension is a constant challenge. By focusing on the select compositions of Tchaikovsky discussed in this paper, educators in both music and ballet can pinpoint the connections between these two fields that are necessary for artists to communicate and collaborate with one another.

III. THE EDUCATIONAL TOOL

Tchaikovsky's three ballets and three later symphonies form a unique cross-section of compositions that can function as an educational tool for improving student comprehension. As a major composer of both Romantic music and Classical ballets, Tchaikovsky's compositions serve as an ideal foundation for establishing historical perspectives. Additionally, the relative familiarity of his compositions, as demonstrated by the survey, provides readily accessible material for introducing structural comparisons. Finally, the wealth of information contained in these six compositions demonstrates a significant collection of unique artistic elements from which to establish strong connections between the fields of music and ballet.

The chronological pairings of these six compositions—*Swan Lake* (1875–76) and the Fourth Symphony (1877); the Fifth Symphony (1888) and *The Sleeping Beauty* (1888–89); and *The Nutcracker* (1891–1892) and the Sixth Symphony (1893)—provide an excellent foundation for students’ mutual understanding of historical, structural, and artistic connections. This chronological progression of Tchaikovsky’s ballets and his Fourth, Fifth and Sixth Symphonies are key to establishing the unique connections between music and ballet. Historical background provides context for the intersection of music and ballet during Tchaikovsky’s time; structural comparisons provide students with direct parallels between music and ballet; and artistic elements such as theme, motif, and instrumentation will be vital for establishing further points of understanding and for initiating discussion between students in music and ballet. As a result, this distinct educational tool promotes the effective presentation of introductory learning material for students in both music and ballet.

A. Historical Perspectives

To begin to establish the connections among Tchaikovsky’s ballets and later symphonies, it is important to consider the historical development of the Romantic era in music and the Classical era in ballet in the 19th century. These two major artistic eras of the 19th century were flipped chronologically between music and ballet. The Romantic era in ballet is defined as having occurred between 1830 and 1850 (with *La Sylphide*, *Giselle*, and *Pas de Quatre* depicting the Romantic ideas of emotion, imagination, and human fragility), whereas the Romantic era in music is generally defined as having occurred throughout the 1800s. Conversely, the Classical era for music is defined as having occurred from approximately 1750 to 1820, whereas the Classical era in ballet occurred in the second half of the 1800s.

Throughout much of the 19th century, music and ballet underwent critical developments and transformations. During the Romantic and Classical eras of this century, music experienced enhanced instrumentation, responded to political developments such as Nationalism, and witnessed the expansion of the symphonic form. At the same time, ballet grew from operatic divertissements into a singular form of dance consisting of multiple-act productions. Ballet experienced substantial technical development and refinement during its Classical era, with a focus on pure and simple ideas of beauty, new levels of proficiency from the corps de ballet, and a more significant purpose of the male danseur all being key to this advancement. By the end of the 19th century, both music and ballet had experienced a full

range of classical and romantic ideas, forms, and styles, many of which were drawn from the literature and artwork of the time. In addition, political developments, the rise of Nationalism, and increased ease of travel all played an important part in the variety of plot locations and the inclusion of characterized folk dances in the full-length ballet. These developments in music and ballet led to great collaborations between composers and choreographers in the late 19th century, particularly the collaboration between Tchaikovsky and choreographers Marius Petipa and Lev Ivanov. The results of their collaborations with *Swan Lake*, *The Sleeping Beauty*, and *The Nutcracker* are not only key examples of Classical full-length ballets but also represent critical turning points in both music and ballet. As a result, these three ballets provide numerous opportunities for analyzing artistic communication and for gaining insight into the collaborative process.

B. Structural Comparisons

Following an introductory review of the historical background of these compositions, the next layer to uncover among these six compositions is their general form and structure. As pivotal large-scale works for the two art forms, these compositions offer substantial material with which to promote mutual comprehension of how symphonic musical compositions and full-length classical ballets are constructed. In the case of the ballet students, who in the survey were significantly more likely to associate “symphony” with the entity rather than the form, Tchaikovsky’s later symphonies are prime starting points for broadening the students’ perspective on the construction of classical music, particularly in regards to the construction of the symphonic form.

In many cases, the structure of the full-length classical ballet can be compared with the structure of a symphony, both of which experienced major developments during the 19th century. It is notable, however, that the structural similarities are not limited to the symphony and the ballet, as similar comparison can be made in regards to operatic structure: “Like an opera, a classical ballet has a scenario divided into acts, and these are subdivided into mimed action sections (*scènes*), danced action scenes (*pas d’action*), and sections of formal dancing (*valse*, *pas de deux*, etc.)” (Brown 110). The ballet, symphony, and opera all contain a similar structure with three to four acts (or movements), a combination of soloists and corps de ballet (or orchestra or chorus), and the establishment of thematic material in the overture, prologue, or first act. Additionally, all three compositional formats serve to establish a problem or plot in the exposition. Following the

often programmatic lead of the exposition, the symphony, opera, and full-length ballet often share similar structural elements, including the development, climax, recapitulation, coda, and finale. It is essential for students to first recognize these structural elements and understand the parallels established between Tchaikovsky's symphonies and ballets in order to proceed with a more in-depth analysis of these compositional forms through their artistic elements.

All three of Tchaikovsky's later symphonies can be used to demonstrate compositional forms, especially the introduction of the Sonata Allegro form. Additional instructional support for introducing compositional forms can be found in the excellent reference guides written by Earl V. Moore and Glenn McGeoch in *Syllabus for the Introduction to Music Literature*, which provide detailed structural analysis for each of Tchaikovsky's later symphonies (Moore and McGeoch 182-193). Such analysis of the symphonies presents a twofold educational tool for both music and ballet students. While this structural analysis provides in-depth compositional material applicable to music students, it can also provide a general overview and visual representation of compositional forms for ballet students. However, these three symphonies also present exceptions to specific compositional forms, which can create a foundation for both inquiry and discussion by music students. While these parallels present opportunities for students in music and ballet to better understand each other's disciplines, they also present an opportunity for educators to present the pros and cons of strictly following specific compositional forms in the development of one's creative works. As a result, students have the opportunity to directly apply the material presented in evaluating and analyzing their own compositions and choreographies.

C. Artistic Elements

Key connections between Tchaikovsky's ballets and later symphonies are found throughout his use of artistic elements such as themes, motifs, and melodies. These connections provide a valuable basis for providing parallels between both compositional forms, as well as for establishing progressive comparisons among these six compositions. In addition, the identification of thematic material and melodic characteristics is critical to unlocking the unique connections between Tchaikovsky's ballets and symphonies.

Tchaikovsky develops meaningful similarities in his compositions through the continual use and imitation of a variety of themes and motifs, and also develops a compositional foundation using his thematic and motivic ideas. Given the chronological progression of

these symphonic and balletic works, it is probable that Tchaikovsky first established thematic and motivic ideas in his ballets and later re-explored these ideas when creating his symphonies, or vice versa in the case of the Fifth Symphony and *The Sleeping Beauty*. Roland John Wiley remarks that “comparisons with *Sleeping Beauty* were inevitable. Laroche observed that Tchaikovsky made ‘innocent loans from his own pocket’ by using in *Nutcracker* devices of style and structure he had already used in *Sleeping Beauty*” (Wiley, *Tchaikovsky’s Ballets* 221). An essential starting point for the educational tool includes several listening examples (Table 1), which demonstrate specific motivic connections between Tchaikovsky’s ballets and later symphonies.

Another example of Tchaikovsky’s use of similar themes, not often realized in current operatic repertoire, is how he borrowed the Act II *pas d’action* of *Swan Lake* from his opera *Undine*. Tchaikovsky had composed *Undine* eight years earlier, and, although he ultimately destroyed this operatic composition, he decided to incorporate the theme of the love duet from *Undine* into the vivid violin solo of Odette and Prince Siegfried’s duet (Brown 114). By using similar thematic and motivic ideas throughout a variety of formats, Tchaikovsky establishes a recognizable style via this extensive collection of creative variations. His compositions acutely demonstrate how to connect bits and pieces of memorable motifs throughout one’s artistic collection. While the degree of Tchaikovsky’s exact compositional intention could be further debated, these variations provide students with a precise pathway of how motivic and thematic ideas can be correlated and developed throughout an artist’s oeuvre.

Throughout *Swan Lake*, *The Sleeping Beauty*, and *The Nutcracker*, Tchaikovsky extensively uses leitmotifs, melodic ideas, and dramatic accents, which are essential for plot and character development in the full-length classical ballet. Tchaikovsky’s use of leitmotifs for his ballets is arguably drawn from the mid-century masterpiece of *Giselle*: “Like most of his fellow-countrymen, he was, at that period of his life, a devotee of the ballet, and had long cherished the idea of producing something of this kind ... His ideal ballet in those days was *Giselle*, the joint production of Théophile Gautier and Adolph Adam” (Newmarch and Tchaikovsky 54). Further, “Adam pioneered the use of leitmotif [for ballet], using certain melodies several times throughout the work, each melody representing a specific character, emotion, or situation ... After Adam, Tchaikovsky and Delibes wrote the first major ballet scores that were truly integral to the production” (Woodstra, Brennan, and Schrott 1551).

| Table 1: Listening examples | | | |
|--|---------------|-----------------|---|
| Composition | Timing | Measures | Motivic Connection |
| Swan Lake Act IV, No. 29 | 0:00–0:44 | 1–21 | Instrumental motif (oboe) |
| Symphony No. 4 2 nd Movement | 1:21–2:01 | 27–47 | |
| Swan Lake Act III, No. 16 | 0:00–0:28 | 1–36 | Instrumental motif (pizzicato strings) |
| Symphony No. 4 3 rd Movement | 1:38–2:00 | 88–103 | |
| Sleeping Beauty Act I, No. 8 | 10:23–10:51 | 146–155 | Melodic tension & development |
| Symphony No. 5 2 nd Movement | 3:36–3:55 | 48–51 | |
| Sleeping Beauty Act II, No. 13 | 1:36–1:55 | 72–88 | Instrumental motif (strings) |
| Symphony No. 5 3 rd Movement | 0:00–0:15 | 1–16 | |
| Sleeping Beauty Act III: Apotheosis | 8:28–8:42 | 422–436 | Melodic motif (horns with strings) |
| Symphony No. 5 4 th Movement | 3:45–4:01 | 393–400 | |
| The Nutcracker Act II, No. 14d | 6:30–7:21 | 130–141 | Melodic and rhythmic motifs |
| Symphony No. 6 1 st Movement | 0:00–0:25 | 1–35 | |
| The Nutcracker Act I, No. 6 | 8:50–9:20 | 160–170 | Instrumental and rhythmic motifs |
| Symphony No. 6 1 st Movement | 2:32–2:43 | 56–60 | |

From the initial use of leitmotifs by Adolph Adam in *Giselle* and development by Léo Delibes in *Coppélia*, Tchaikovsky continued to expand the use of leitmotifs in the ballet setting as a way to represent a specific character or group of characters. This is immediately apparent in *Swan Lake* with the contrasting characters of Odette and Odile. In Act IV of *Swan Lake*, “the short orchestral prelude presents the

opposing sides, a gracious theme on the oboe (very much Odette and the swans' orchestral surrogate) introducing music characteristic of the swans, the violent music that follows forewarning of the evil forces that will finally seem triumphant" (Brown 112). Tchaikovsky's use of leitmotifs, melodic ideas, and dramatic accents to enhance characterization and assist with plot development provides students with a clear outline for identifying the connections between instrumentation and characterization.

Tchaikovsky's rich examples of motif and melody, combined with recognizable structure and plot in these select compositions, allow students to gain extensive insight into compositional design. With his use "of melodic outline combined with emphatic expression of his ideas, heightened by richness of orchestral colouring" (Russian Anthology 156), Tchaikovsky is able to amplify his symphonies and ballets into something more than simple programmatic works, *divertissements*, or dance accompaniments. These unique motivic and melodic connections are particularly apparent among these six compositions.

All three ballets, as well as the Fourth, Fifth, and Sixth Symphonies, contain the powerful motif of the descending scale pattern. It is initially presented in a quick tempo as the foreboding entrance of Odile in Act III of *Swan Lake*, as well as in the dramatic tension of Act IV. The opening of the Fourth Symphony contains a very apparent use of this motif, and there are exceptionally similar parallels between the 2nd Movement of the Fifth Symphony and the Rose Adagio in Act I of *The Sleeping Beauty*. Interestingly, the ominous descending scale in the Rose Adagio is contrasted by an ascending scale in the strings, perhaps representative of the juxtaposition of the joy of Aurora's 16th birthday and the foreboding of her pricked finger. In addition, "Tchaikovsky made unambiguous reference to the Fifth [Symphony] in *The Sleeping Beauty* when Aurora rises in a vision from her hundred years' sleep" (Wiley, *Tchaikovsky* 334). Tchaikovsky employs the descending scale in a dramatic fashion once again in Act II of *The Nutcracker* and in the middle of the 1st Movement of the Sixth Symphony, in a syncopated pattern in both instances.

Wiley suggests that these "descending figures [scale patterns] ... surpass the details and hint at irresolution and the unattainable" (Wiley, *Tchaikovsky* 129). In each case, the descending scale patterns listed in Table 2 act as a bridge between an initial thematic statement and the tension to come. These create an intriguing starting point to stimulate interest and inquiry for music and ballet students. As illustrated by Table 2, the chronological progression of Tchaikovsky's use of these

descending scale patterns demonstrates both the establishment of thematic material and the development of compositional variation. The considerable repetition and variation of these descending scale patterns is a distinctive characteristic of Tchaikovsky's entire collection of compositions and makes for excellent study material for both musicians and dancers.

Table 2: Variations on the descending scale pattern

| Composition | Timing | Measures | Variation of Motif |
|-----------------------------------|------------|----------|---------------------|
| Swan Lake Act IV, No. 29 | 3:10–3:20 | 88–92 | Established |
| Symphony No. 4 1st Movement | 0:10–0:20 | 5–7 | Established |
| Swan Lake Act III, No. 18 | 1:00–1:05 | 39–40 | Faster tempo |
| Symphony No. 5 2nd Movement | 9:55–10:08 | 140–142 | Melodic contrast |
| Sleeping Beauty Act I, No. 8 | 3:30–3:40 | 47 | Foreboding contrast |
| The Nutcracker Act II, No. 14a | 2:30–2:55 | 41–46 | Syncopated |
| Symphony No. 6 1st Movement | 9:35–9:55 | 190–197 | Syncopated |

IV. POTENTIAL APPLICATIONS OF THE EDUCATIONAL TOOL

The use of select compositions by Tchaikovsky as an educational tool can help students in discovering the similarities between the historical, structural, and artistic aspects of the symphony and the ballet. Once students have a grasp of these aspects, they can begin to apply them to their own creative works and collaborative projects. For them to do so, in both the academic setting and the real world, it is important for music and ballet students to communicate effectively with one another. In the context of Tchaikovsky, three key elements of communication between music and ballet can be presented by the teacher: the subtle nuances of tempo, the issues of rhythmic contrast and counting, and the challenges of collaboration.

A. *Tempo*

Tempo, style, and accent can be a source of animosity between the musician/conductor and dancer/choreographer. An exceedingly quick tempo could result in messy rhythms and unclear accents for both the musicians and dancers. Conversely, a dragging tempo in a grand allegro section will negatively affect the buoyancy in the choreography and cause the dancer(s) to feel weighed down by the music. The “Little Swans” and “Big Swans” variations in *Swan Lake* (Act II: No. 13, IV and VI) are prime examples of these two issues of tempo, with intricate group footwork in the former and plenty of powerful grand allegro movements in the latter. Even when following the originally specified tempos, which could be rather vague in the case of Tempo di Valse for No. 13, VI (Tchaikovsky *Le Lac Des Cygnes* 365), there is still room for discrepancies unless more recent editions of the score are used with specific metronome markings notated. Additionally, spatial restrictions, dancer capabilities, and choreographic development in new reconstructions can all affect the nuances of tempo. Ultimately, the human element is of key consideration in this delicate yet rewarding relationship between the musician/conductor and dancer/choreographer.

Tempos are of chief concern with waltzes, as tempo can drastically affect the overall quality of movement and efficiency of most steps, particularly those generally paired with a triple meter such as balancés and waltz turns. Waltzes stand out in Tchaikovsky’s repertoire, with rhythm, line, and phrasing blended together to create a characteristic sound. For the music student, the Act I Waltz from *The Sleeping Beauty* and “Waltz of the Flowers” from *The Nutcracker* both provide excellent material for a discussion of the lift found in triple meter and how tempo can impact the choreographic usage of this lift.

Tchaikovsky and Petipa established tempos quite collaboratively: “Tchaikovsky, knowing nothing of the choreography or of the performers, had indicated tempo in accordance with Petipa’s instructions—with words alone. The metronome markings would seem to represent Petipa’s precise determinations of tempo after going over the music” (Wiley, *Tchaikovsky’s Ballets* 151). Their collaboration can provide insight for music and ballet students into the composer’s and choreographer’s arrangement of tempos and rhythms, as well as into how they specifically collaborated in creating these compositions; however, students can also be challenged to consider and discuss how the technical development of dancers in the century since the premieres of these ballets may affect the use of the originally agreed-upon tempos.

B. Rhythms, Counting, and Musical Forms

Relating to the issues of tempo, rhythmic contrast and counting is an added concern for both musicians and ballet dancers. Unique rhythmic patterns appear in several of Tchaikovsky's compositions, especially in the convergence of duple and triple patterns. While unique rhythmic patterns and fluctuating tempos create interest for the listener, they create challenges for musicians and ballet dancers. For example, the triplet half-note patterns in the Finale of *Swan Lake* must be played calmly yet strongly to keep the movement or mime clean, but not too slow otherwise the movement or mime becomes heavy (Tchaikovsky, *La Lac des Cygnes* 605). Just a simple adjustment to conducting in one (with the downbeat accented once per measure) instead of two (with two beats conducted per measure, in contrast to the triplet half-note pattern) in this section can drastically change the movement quality and communication of mime in this section.

Tchaikovsky's significant use of hemiolas throughout his symphonies and ballets, in which he arranges duple rhythmic patterns to stand out within a composition in triple meter, is particularly apparent in the waltzes of his ballet compositions. The rhythmic construct of a hemiola creates both a complex choreographic problem and a unique choreographic opportunity. For example, the "Waltz of the Flowers" in *The Nutcracker* contains several phrases with hemiolas, which can cause chaos for the corps de ballet dancers and a mess of the choreography if not counted correctly (Tchaikovsky, *Casse-Noisette* 385); however, the use of hemiolas also allows for movement to be contrasted with the typical triple-patterned steps mentioned in the earlier discussion of tempo. These contrasting rhythmic changes can elicit a feeling of visual, auditory, or kinesthetic counterpoint for the audience. The "Waltz of the Snowflakes" in *The Nutcracker* also demonstrates Tchaikovsky's use of contrasting rhythms and poses plenty of challenges for the dancers and choreographer, especially in the dramatic melodic development and underlying meter change at Measure 265 (Tchaikovsky, *Casse-Noisette* 218). In this piece, Wiley believes that "Tchaikovsky carries rhythmic disjunction to the furthest point of any of his ballets" (Wiley, *Tchaikovsky's Ballets* 235). As the "Waltz of the Snowflakes" is one of the most recognizable pieces in *The Nutcracker*, it is essential for musicians, conductors, dancers, and choreographers to understand the rhythmic complexity of this finale to Act I of the ballet.

When tackling issues of rhythmic complexity, counting can be a tool that both musicians and ballet dancers can use to translate the rhythmic complexity of music into dance, or vice versa; however,

counting is often a contrasting element between musicians and dancers in the communication between these fields. For example, a phrase of eight counts for ballet dancers is more often referred to by musicians as a phrase of eight measures or bars. Depending on the meter, however, counts and phrases can increasingly lead to miscommunication between musicians and ballet dancers. For example, the second half of the Neapolitan character divertissement in *Swan Lake* (Tchaikovsky *Le Lac Des Cygnes* Vol. II 182) demonstrates a juxtaposition of counting and phrasing within the musical form of a Tarantella. The Tarantella can initially be a challenging musical form for ballet students to count, as the concept of duple versus triple meter suddenly contrasts with how a Tarantella is counted in duple yet written in 6/8; however, the introduction of the Tarantella musical form, along with this recognizable example from *Swan Lake*, provides students an opportunity to discuss the difference between musicians' counts and dancers' counts.

In addition to the Tarantella, Tchaikovsky's compositions showcase numerous examples of musical forms that are specifically used for teaching ballet. The musical forms presented in Tchaikovsky's compositions can offer students practice for understanding precise rhythmic patterns and counting methods. For example, in the construction of the solo fairy variations in *The Sleeping Beauty* "Tchaikovsky has modelled most of them on what would be hackneyed formulas in Minkus: a tarantella (Var. II), a polka (Var. IV), a galop (Var. V), and a waltz (Var. VI). He raises each form to a higher level, and conceals the metrically bare dance formula in the pursuit of the highest rhythmical-intonational interests" (Wiley, *Tchaikovsky's Ballets* 130). By introducing musical forms with a familiar entity, such as the character divertissements of *Swan Lake* or the solo fairy variations of *The Sleeping Beauty*, a collection of recognizable melodies can be paired with the requisite musical forms for teaching ballet. And as many of the musical forms used for ballet class are drawn from the repertoire of full-length classical ballets, Tchaikovsky's ballet compositions provide an opportune starting point for connecting familiar themes and rhythmic patterns to the necessary accompaniment for teaching ballet and thus enhancing a student's pedagogical and choreographic preparation.

C. Challenges of Collaboration

An auxiliary component to the construction of a creative work is the element of collaboration, as having multiple artists involved in a creative work greatly affects the construction and outcome of the work.

Both *Swan Lake* and *The Nutcracker* have been considered initial failures, and the latter offers a prime example of the influence that multiple artists can have on the success or failure of a collaborative project. For instance, the structure of the full-length classical ballet is often first established by a librettist, and this structure can either support or encumber the composer in creating the musical composition (as well as the choreographer in formulating the choreography). For example, the libretto of *The Nutcracker* was created from the much darker tale of *The Nutcracker and the Mouse King* by E.T.A. Hoffmann, but librettist Alexandre Dumas père changed the original tale to suit the light-hearted nature of a fairy-tale ballet. In doing so, Dumas created a challenge for Tchaikovsky in matching this light-hearted plot, given the weight and tension found in the music of his previous two ballets. Although Tchaikovsky was not thrilled with the libretto, he eventually went along with the production in collaboration with Dumas, Petipa, and Ivanov as “prospects must have seemed bright. Fresh from the success of *Sleeping Beauty*, the same team was to produce another magnificently staged ballet based on a children’s tale” (Wiley, *Tchaikovsky’s Ballets* 193). However, the original production of *The Nutcracker* was not well received in 1892, primarily because of the libretto: “it is a pity that so much fine music is expended on nonsense unworthy of attention, but the music in general is excellent: that designated for dances is *dansante* and that designated for the ear and for the fantasy is imaginative. Of Tchaikovsky’s three ballets ... *Nutcracker* is best, its music indeed not for the normal ballet audience” (Wiley, *Tchaikovsky’s Ballets* 221). This is an example of the ever-present risk in artistic collaboration in that all the parties involved may be equally prepared to design the best possible outcome, but none is willing to concede that their ideas may not be feasible or appreciated by current audiences.

Each of these compositional details and artistic challenges in the fields of music and ballet are readily showcased in Tchaikovsky’s compositions. By identifying and addressing how these specific details and challenges correspond between the two fields, students are presented with a foundation that both enables them to understand each other’s field and also to communicate with each other. As musicians and ballet dancers become familiar with the six select compositions presented in this paper, they will be prepared to go beyond Tchaikovsky’s repertoire and apply these ideas throughout their training, performance, and creative process.

VI. CONCLUSION

While music and ballet are naturally interconnected, the educational process and artistic development in the two fields are not always connected until students reach the professional setting. Identifying critical links and points of interaction in Tchaikovsky's compositions allows music and ballet students to develop essential training and communication tools: 1) Dancers become more aware of rhythmic patterns and apply this awareness to their movement quality and musicality. 2) Choreographers have the opportunity to delve deeper into a score and listen for unique nuances to enhance their kinesthetic response to the music. 3) Musicians become more adept at natural phrasing and stylistic quality. 4) Conductors gain insight into appropriate tempos and artistic intention. 5) Educators in both music and ballet can tailor their instructional methods such that they further the goals of their students.

Furthermore, collaboration between music and ballet allows students and artists to go beyond conventional expectations and reach towards a higher echelon of artistic creation. The challenges of the collaborative process can develop a student's creativity and problem-solving ability. The benefits associated with artistic collaboration enable a student to gain a better perspective and understanding of various art forms, as well as enhance his or her experience in the academic or professional setting. Students studying to be musicians, conductors, dancers, and choreographers may all benefit from a greater understanding of how Tchaikovsky's compositions significantly enhanced the symbiotic relationship between music and ballet. The six compositions presented in this paper by no means suffice to formulate the relationship between music and ballet in its entirety. They merely provide a foundation that in turn provides excellent opportunities to connect music and ballet. Employing the significant influence of Tchaikovsky's compositions in the fields of music and ballet is a means to an end, a pathway towards a more comprehensive study and understanding of these two associated art forms.

Bibliography

Brown, David. *Tchaikovsky: The Man and His Music*. New York: Pegasus Books, 2007. Print.

Moore, Earl V, and Glenn McGeoch. *Syllabus for the Introduction to Music Literature*. Ann Arbor, Mich.: Edwards, 1959. Print.

Newmarch, Rosa, and Peter I. Tchaikovsky. *Tchaikovsky; His Life and Works: With Extracts from His Writings, and the Diary of His Tour Abroad in 1888*. St. Clair Shores, Mich: Scholarly Press, 1970. Database.

Russian Anthology. "Tchaikovsky, Psychology, and Nationality: A View from the Archives." *19th-Century Music* 35.2 (2011): 144-61. Web. 21 Mar. 2015.

Tchaikovsky, Peter Ilich. *Casse-Noisette: Ballet Féerie en 2 Actes, Op. 71*. New York: Broude Brothers, 1951. Database.

Tchaikovsky, Peter Ilich. *Le Lac Des Cygnes: Ballet en quatre actes, Op. 20*. Moscow: State Music Publishing, 1978. Print.

Tchaikovsky, Peter Ilich. *The Sleeping Beauty: Ballet in Three Acts with a Prologue, Op. 66*. Boca Raton: Edwin F. Kalmus & Co., n.d. Print.

Tchaikovsky, Peter Ilyitch. *Fourth, Fifth and Sixth Symphonies in Full Score*. Mineola, NY: Dover Publications, 1979. Print.

Tchaikovsky, Pyotr Ilyich. *Tchaikovsky—100 Supreme Classical Masterpieces* (Various Artists). X5 Music Group, 2010. MP3.

Tchaikovsky, Pyotr Ilyich. *Tchaikovsky: Sleeping Beauty—Nutcracker Complete Ballets* (Vladimir Fedoseyev & Moscow RTV Symphony Orchestra). SLG, 2008. MP3.

Tchaikovsky, Pyotr Ilyich. *Tchaikovsky: Swan Lake* (André Previn and London Symphony Orchestra). Warner Classics, 1976. MP3.

Wiley, Roland John. *Tchaikovsky*. Oxford: Oxford University Press, 2009. Print.

Wiley, Roland John. *Tchaikovsky's Ballets: Swan Lake, Sleeping Beauty, Nutcracker*. Oxford: Clarendon Press, 1985. Print.

Woodstra, Chris, Gerald Brennan, and Allen Schrott. *All Music Guide to Classical Music: The Definitive Guide to Classical Music*. San Francisco, CA: Backbeat Books, 2005. Print/Database.

Appendix

SURVEY

Collaborative Communication Tools in Music and Dance Education

1. Are you primarily a:
☐ Musician ☐ Dancer
2. Years of performing experience:
☐ None ☐ 1-2 years ☐ 3-5 years ☐ 6-10 years ☐ 10+ years
3. Please pick the option that applies to your answer in Question 1:

A) As a Musician, what is your foremost question or interest with ballet music?

B) As a Dancer, what is your foremost question or interest with classical music?
4. First thing that comes to mind with the following words:
Tchaikovsky _____
Ballet _____
Symphony _____
5. List the works of Tchaikovsky that you are familiar with as either a musician or dancer:

Institutional Review Board tracking number: 01387
(Implied Consent Letter included at time of Survey)

Effects of mercury (II) chloride exposure on life parameters and Hsp70 expression in brine shrimp *Artemia franciscana*

Dustin Ingraham and Nicole Berthélémy
Weber State University

Abstract

Artemia franciscana (brine shrimp) were exposed to toxins from the Great Salt Lake, so the objectives of this work were 1) to define the acute and chronic effects of mercury (II) chloride (HgCl_2) on *Artemia*'s life parameters and 2) to quantify *Artemia*'s heat-shock protein 70 (Hsp70) response to HgCl_2 exposure. All *Artemia* exposed to at least $10^{-1} \text{ g.L}^{-1} \text{ HgCl}_2$ for 24 hours died. The highest concentration with no observable adverse effect was $10^{-5} \text{ g.L}^{-1} \text{ HgCl}_2$. All *Artemia* raised in 10^{-2} g.L^{-1} or higher HgCl_2 concentrations died before reaching maturity. *Artemia* placed in 10^{-4} and $10^{-3} \text{ g.L}^{-1} \text{ HgCl}_2$ matured more slowly than the control and produced smaller broods. The median 50% lethal concentration (LC50) was $7 \times 10^{-2} \text{ g.L}^{-1} \text{ HgCl}_2$ (or 0.26 mM inorganic mercury Hg^{++}). Dying *Artemia* exposed to 10^{-3} g.L^{-1} (3.7 mM) HgCl_2 or higher for 24 h strongly expressed Hsp70. *Artemia* surviving a 48-h exposure in 10^{-3} or $10^{-4} \text{ g.L}^{-1} \text{ HgCl}_2$ expressed Hsp70 in higher amount compared with the control. *Artemia* in 10^{-6} g.L^{-1} or lower HgCl_2 concentrations had Hsp70 levels comparable with the

control. Thus, Hsp70 is a potential candidate for stress diagnostic at a time when Artemia is not yet showing visible signs to mercury toxicity.

Introduction

Artemia franciscana (brine shrimp) and *Ephydra spp.* (brine flies) from the Great Salt Lake are an important source of food for many migratory and resident bird species (Belovsky et al., 2011; Wurtsbaugh et al., 2011). Since the Great Salt Lake does not have an outlet, the concentration of some compounds present in the lake most likely are increasing over time. Routine tests in 2005 conducted by the U.S. Environmental Protection Agency (EPA) on several bird species inhabiting the Great Salt Lake measured the highest mercury (Hg) level ever registered in waterfowl in the USA. This led to government advisories against consumption of meat from duck and other waterfowl species (Scholl and Ball, 2005; Conover and Vest, 2009). The likely sources of the Hg are airborne dust from gold mines in Nevada (Naftz et al., 2008; Peterson and Gustin, 2008; Jones and Wurtsbaugh, 2014) and wastes dumped by local industries in streams and rivers emptying into the Great Salt Lake (Clarkson, 2002). Total Hg in the Great Salt Lake deep water reaches 97.10^{-9} g/L (Naftz et al., 2008), almost fifty times the maximum acceptable level of Hg of 2.10^{-9} g/L (or 1.10^{-11} M) set by the EPA for drinking water (EPA, 2009).

Mercury bioaccumulates through the food chain, first in algae, then in *Artemia* and brine flies, and finally in bird predators (Naftz et al., 2008). *Artemia*'s filter feeding habits and planktonic habitat make it a convenient sentinel species for Hg monitoring. This species has already been a popular subject of many toxicological studies focused mostly on various bioindicators such as population abundance, individual survival, growth, maturation rate, fertility, and cyst hatchability (Nunes et al., 2006; Dvorak et al., 2012).

Exposure to mercury induces the formation of reactive oxidative species (ROS) that cause a wide range of cell damages (Stohs and Bagchi, 1995). The cell attempts to control these damages by producing reducing compounds that mitigate the effects of the ROS and by upregulating enzymes and proteins that neutralize or repair damage (Davies, 1999). Among these proteins, heat shock protein 70 (Hsp70) is well-known to protect from many types of stress, especially from high temperatures (Kültz, 2005).

The ability to detect changes in several biomarkers possibly involved in mitigating the damaging effect of HgCl_2 on the cell can provide a means to measure and monitor the level of stress inflicted on

a population. Awareness of a population stress level, when the effect of Hg on the animals is not yet visible, might provide a warning about impending population decline and give us a tool to better manage our environment and resources.

Laboratory studies are ideal for highlighting the effects of a single toxin since this effect is difficult to measure in the natural environment. Individuals are likely under the influence of many different types of stress, including exposures to organic and/or non-organic toxins, changes in temperature and water composition, and variations in feeding opportunities. While inference of laboratory results to field data are subject to possible error and uncertainty, laboratory studies are a necessary starting point to unravel these many effects.

The objectives of this study were (1) to analyze the acute and chronic effects of increasing levels of HgCl_2 on *Artemia* life parameters and (2) to determine the effect of HgCl_2 on Hsp70 expression in adult *Artemia*.

Materials and Methods

Artemia husbandry

Great Salt Lake *Artemia* cysts bought from Brine Shrimp Direct (Ogden, Utah) were hatched and raised in a seawater (SW) solution made of 30 g.L⁻¹ Instant Ocean (IO) salt (Aquarium Systems, Mentor, Ohio). The nauplii (larvae) to be used for lifetime exposure were raised to maturity in fully aerated salt solution and fed with algal densities of 30–50 *Tetraselmis suecica* per µl (Texas University Algae Collection, LB 2286). Salt solutions and algal cultures were renewed as needed, about every two to three days. All *Artemia* were placed in an environmental chamber with constant light (40W fluorescent light at a distance of 20 cm) and controlled temperatures (within 0.1°C) of 20, 23, and 25°C, depending on the experiment.

Effect of acute (24-h) mercury (II) chloride exposure on adult *Artemia* survival

We measured the survival rate in adults after a 24-h exposure at various HgCl_2 concentrations: 0 (control), 10⁻⁵, 10⁻⁴, 10⁻³, 10⁻², 10⁻¹, and 1 g.L⁻¹. We tested two different temperatures and three different salinities because these factors vary with the seasons and the lake location. In addition, these factors might interact and modulate their effects on mercury toxicity. Twenty fully grown male and female *Artemia* were placed in petri dishes with 100 ml of 30, 90, and 150 g L⁻¹ salt solutions. The effect of HgCl_2 was tested at two temperatures,

20°C and 25°C. All conditions were replicated three times (7 Hg^{++} concentrations \times 3 salinities \times 2 temperatures \times 3 replicates).

Effects of long-term mercury (II) chloride exposure on *Artemia* survival, maturation, and fertility

The long-term exposure measured the effects on mortality, maturation time, and fertility. About 30 larvae (1 day old) were placed in large petri dishes containing 200 ml of 30 g.L^{-1} salt solutions, at 23°C, with an abundant supply of algae. Because of logistical limitations, these experiments were done in two series, back to back, in time. Control (0), 10^{-6} , and 10^{-5} g.L^{-1} were tested in a first series and 0, 10^{-4} , 10^{-3} , 10^{-2} , 10^{-1} , and 1 g.L^{-1} HgCl_2 in a second series. The presence of a control in each series tests for the unknown effects within the series. Survival was measured as the percentage of *Artemia* surviving to maturity. The time to maturation, measured in females only, was the number of days from 1-day-old larvae to the spawning of the first brood. Fertility, also measured in females only, was indicated by the numbers of eggs per brood. Each set was replicated 5 times.

Effects of mercury (II) chloride on *Artemia* Hsp70 expression

For the effect of acute exposure on the expression of Hsp70, new sets of 20 adult *Artemia* were placed in 100-ml petri dishes, filled with a well-aerated clear salt solution (30 g.L^{-1}), at 23°C, and in HgCl_2 concentrations ranging from 1 g.L^{-1} to 10^{-8} g.L^{-1} . Dead *Artemia* were removed. *Artemia* near death but still moving after 24 h were collected, homogenized, and frozen. Samples of 10 surviving *Artemia* were harvested after 48-hour exposure.

For the chronic exposure study, sets of 30 adult *Artemia* were placed in 150-ml petri dishes, in conditions similar to the above experiment, except that they were fed. *Artemia* were exposed to the mercury concentrations described above for 7 days, after which a sample of 10 *Artemia* was harvested.

Sample preparation, SDS-PAGE and Western blots

Sample preparation, SDS-PAGE, and Western blots were as described in Clegg et al. (1995, 2000). The primary antibody was human Hsp70 monoclonal antibody (StressGen, SPA-810). After staining, a Biorad image analyzer was used to photograph the membranes and analyze the band intensities. The control band, in each experiment, was used as a reference to analyze the changes induced by the treatments. Samples with similar protein concentrations were

loaded in each lane. A Biorad prestained protein ladder (L) was used for molecular weight control.

Statistical analysis

Differences in binomial data such as survival were tested with the non-parametric G tests. William's correction for small samples was applied to the G tests (Sokal and Rohlf, 1995). After homogeneities of variance were checked with Levene's test, data on maturation times, brood sizes, and biochemical analyses were tested with univariate ANOVA using SPSS program (IBMSPSS 19, software licensed to Weber State University).

Results

Effect of Hg on *Artemia* life parameters

Acute exposure

One hundred percent of the *Artemia* died after 24 h exposure to 1 g.L⁻¹ HgCl₂, regardless of salinity or temperature. Exposure to 10⁻¹ g.L⁻¹ HgCl₂ at 25°C killed 90% or more of the shrimp while about 20% survived if placed at 20°C. *Artemia* subjected to 10⁻² g.L⁻¹ HgCl₂ or less had a lower mortality rate, with about 15% or less dying at 20°C and 40% or less at 25°C. Overall, HgCl₂ was more toxic at higher temperatures (G>1000, p<0.001, Fig. 1).

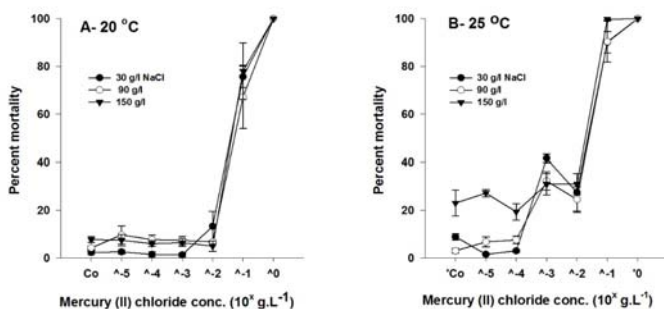


Figure 1: Effect of acute mercury (II) chloride exposure on *Artemia franciscana* from the Great Salt Lake following a 24-hour exposure at 20°C (A) and 25°C (B). For conversion to Hg⁺⁺ toxicity, 1 g.L⁻¹ HgCl₂ = 0.74 g.L⁻¹ Hg⁺⁺ = 3.7 mM Hg⁺⁺. Error bars show the standard error.

The highest concentration with no observable adverse effect was 10^{-4} g.L⁻¹ HgCl₂ in adults at 25°C, at 30 and 90 g.L⁻¹ SW. The 50% median lethal concentration (LC50) is 0.07 g.L⁻¹ HgCl₂ (or about 0.052 g.L⁻¹ Hg⁺⁺ or 0.26 mM Hg⁺⁺).

Long-term exposure

The mortality rates of the two controls were 19.6% and 36.3% in the first and second series, respectively (Table 1). Because the difference between these controls was significant ($G=4.13$, $p<0.05$), the two experiments were analyzed separately.

The lowest HgCl₂ concentrations, 10^{-5} and 10^{-6} g.L⁻¹ HgCl₂, did not affect *Artemia* as there was no significant difference in mortality, maturation rate, and brood number among control and treatments. They matured in about 30 days (s.e=2.3–2.4) and produced on average 42 (s.e=6.7), 36 (s.e=7.32), and 36 (s.e=7.8) eggs per brood (Table 1, series 1). Respective mortality rates of *Artemia* exposed to 10^{-4} and 10^{-3} g.L⁻¹ HgCl₂ were 50.5% and 43.5%, higher than the control but not statistically significant ($G=4.279$, $df=2$, $p=0.118$, Table 1).

Artemia franciscana placed in 10^{-4} and 10^{-3} g.L⁻¹ HgCl₂ matured at a significantly slower rate, in 51 and 43.5 d, respectively, compared with 36.2 d in the control ($F=17.64$, $p<0.001$). The numbers of eggs per brood produced under these conditions were significantly lower, 24 and 34, respectively, compared with 52 eggs per brood in the control ($F=8.9$, $p=0.006$, Table 1, series 2).

Table 1: Effect of lifetime mercury (II) chloride exposure on Great Salt Lake *Artemia franciscana* survival, maturation rate, and fertility (mean \pm SE)

| Variable | Series 1 | | | Series 2 | | |
|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | 0 | 10^{-6} | 10^{-5} | 0 | 10^{-4} | 10^{-3} |
| Mortality (%) | 19.6 \pm 5.3 | 25.7 \pm 1.3 | 14.5 \pm 8.0 | 36.3 \pm 5.4 | 50.5 \pm 9.2 | 43.5 \pm 5.4 |
| Maturation rate | 29.9 \pm 2.3 | 31.4 \pm 2.4 | 31.2 \pm 2.4 | 36.2 \pm 4.6 | 51.0 \pm 4.0 | 43.5 \pm 5.1 |
| Fertility | 41.9 \pm 6.7 | 36.5 \pm 7.3 | 35.7 \pm 7.8 | 51.8 \pm 9.1 | 23.9 \pm 7.6 | 34.1 \pm 7.4 |

Sets of thirty 1-day old larvae were raised to maturity in a first run in 0, 10^{-6} , and 10^{-5} g.L⁻¹ HgCl₂ and in a second run in 0, 10^{-4} , and 10^{-3} g.L⁻¹ HgCl₂. All treatments were replicated five times. Mortality is the percentage of *Artemia* dying before maturation. Maturation time is the number of days necessary for a female *Artemia* to spawn its first brood. Fertility is the number of larvae or cysts present in the first brood.

All *Artemia* exposed to 10^{-2} g.L⁻¹ or higher HgCl₂ concentrations died before reaching maturity.

Effect of HgCl₂ on Hsp70

The expression of Hsp70 was 6 to 8 times stronger in dying *Artemia* (removed from the 10^{-3} , 10^{-2} , and 10^{-1} g.L⁻¹ dishes, after 24 h) compared with the control (Fig. 2).

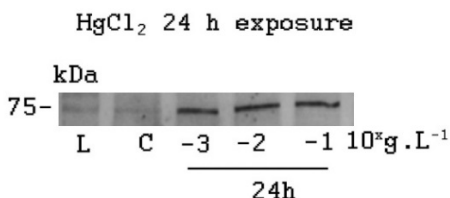


Figure 2. Hsp70 expression in dying *Artemia franciscana* exposed for 24 h to 10^{-3} , 10^{-2} , and 10^{-1} g.L⁻¹ HgCl₂.

The survival rate after 48-h exposure was 0% in 10^{-1} and 10^{-2} g.L⁻¹ HgCl₂, 40% in 10^{-3} g.L⁻¹ HgCl₂, 80% in 10^{-4} g.L⁻¹ HgCl₂, and 100% in the remaining treatments. The surviving *Artemia* exposed to HgCl₂ for 48 h appeared in better health and did not express Hsp70 as strongly as the dying ones. While the expression in *Artemia* placed in 10^{-8} , 10^{-7} , 10^{-6} , and 10^{-5} g.L⁻¹ was comparable with the control band, Hsp70 expression was noticeably upregulated in *Artemia* placed in the 10^{-4} and 10^{-3} g.L⁻¹ HgCl₂ solutions (1.3- and 1.9-fold, respectively, Fig. 3).

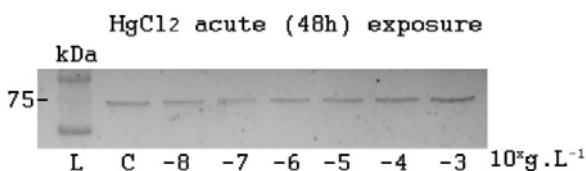


Figure 3. Hsp70 expression after 48-h exposure to HgCl₂ concentrations ranging from 0 to 10^{-8} g.L⁻¹. L represents the protein ladder with only the 75-kDa band shown, C shows the control data.

In the chronic or 7-day exposure, 100% of *Artemia* placed in HgCl₂ solutions of 10^{-5} g.L⁻¹ HgCl₂ or lower survived. *Artemia* mortality rates were 10% and 70%, respectively, in the 10^{-4} and 10^{-3} g.L⁻¹ HgCl₂ solutions. *Artemia* placed in 10^{-2} and 10^{-1} g.L⁻¹ had a 100% mortality rate and thus were not included. Compared with the control,

Hsp70 expression gradually increased, with a fivefold increased expression in *Artemia* placed under 10^{-6} , 10^{-5} , and 10^{-4} g.L⁻¹ HgCl₂ and over an eightfold expression in the *Artemia* surviving in 10^{-3} g.L⁻¹ HgCl₂ (Fig. 4).

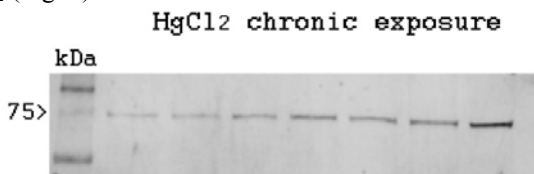


Figure 4. Hsp70 expression after a 7-day exposure to HgCl₂ concentrations ranging from 0 to 10^{-8} g.L⁻¹. L stands for protein ladder, C for control (0 g.L⁻¹ HgCl₂).

Discussion and Conclusion

Studies on the effects of exposure to mercury on *Artemia* survival are summarized in Table 2. Since the toxicity of HgCl₂ is due to the inorganic form of mercury (Hg⁺⁺), the g.L⁻¹ HgCl₂ concentrations have been converted to molar Hg⁺⁺ by multiplying by 0.0037.

Our LC50 estimate, around 0.26 mM Hg⁺⁺, for a 24-h exposure of adult *Artemia* has a similar albeit higher range than most reported values. Wisely and Blick (1967) obtained a larval LC50 after 2-h exposure at 9 mM Hg⁺⁺ while Corner and Sparrow (1956) reported a larval LC50 after 2.5-h exposure at 2.94 mM Hg⁺⁺. LC50s measured over 24 h, predictably, resulted from lower Hg⁺⁺ exposure, such as 9.2 µM Hg⁺⁺ (larvae) and 0.075 mM Hg⁺⁺ reported, respectively, by Sleet and Brendel (1985) and Leis et al. (2014). Bhattacharjee et al. (2013) reported a 24-h LC50 at a very low 0.08 nM, a range nearly 10^{-6} smaller than our values; however, inconsistencies in their article, such as using ng/L and mg/L interchangeably, suggest that this value might not be accurate. Brown and Ahnassullah (1971) reported a 25-h LC50 at 3.7 µM. Cunningham and Grosh (1978) obtained a 50% mortality, after a 10-day exposure at 0.037 µM Hg⁺⁺. In lifespan studies, Sarabia et al. (1998) found that exposure to 25 nM Hg⁺⁺ (0.125 nM) decreased *Artemia* lifespan by two thirds, from an average of 38 days in the control down to an average of 13 days in the shrimp exposed to Hg⁺⁺.

Several authors studied the effect of Hg⁺⁺ on *Artemia*'s egg and larval stages. The rate of emergence and hatching of *Artemia* larvae decreased noticeably in the presence of ≥ 0.1 µM Hg⁺⁺ (Go et al., 1990). Inorganic Hg delayed development at concentrations as low as 0.01 µM. Higher concentrations induced developmental deformities (Go et

al., 1990). Nauplii born from parents exposed to HgCl_2 also had a significantly lower survivorship (Cunningham and Grosh, 1978).

The increased mortality at higher temperatures is likely due to an increase in *Artemia* metabolism and possibly HgCl_2 intake, suggesting more deleterious effect of HgCl_2 in summer than in winter. Interestingly, salinity had no effect on HgCl_2 toxicity, implying that

Table 2: Summary of studies of *Artemia* LC50 after exposure to inorganic mercury

| Species (citation) | <i>Artemia</i> life stage | Mortality | Exposure time | Dose in original citation | mM Hg^{++} |
|-------------------------------------|---------------------------|-----------|---------------|---|---------------------|
| Unknown (Wisely and Blick 1967) | Nauplii | LC50 | 2 h | $9.0 \cdot 10^{-3} \text{ M } \text{Hg}^{++}$ | 9 mM |
| Unknown (Corner and Sparrow 1956) | Nauplii I | LC50 | 2.5 h | $800 \text{ mg.L}^{-1} \text{ HgCl}_2$ | 2.94 mM |
| Canada (Sleet and Brendel 1985) | Nauplii | LC50 | 24 h | 2.5 ppm HgCl_2 | 9.2 μM |
| GSL (Bhattacharjee et al. 2013) | Nauplii I | LC50 | 24 h | $16.12 \text{ ng.L}^{-1} \text{ Hg}^{++}$ | 0.08 nM |
| GSL (Leis et al. 2014) | Nauplii III | EC50 | 24 h | $15 \text{ mg.L}^{-1} \text{ Hg}^{++}$ | 0.075 mM |
| GSL (Present work) | Adult | LC50 | 24 h | $70 \text{ mg.L}^{-1} \text{ HgCl}_2$ | 0.26 mM |
| Unknown (Brown and Ahnasullah 1971) | Adults | LC50 | 25 h | 1 ppm HgCl_2 | 3.7 μM |
| Unknown (Corner and Sparrow 1956) | Nauplii I | LC50 | 48 h | $25 \text{ mg.L}^{-1} \text{ HgCl}_2$ | 0.092 mM |
| SF (Cunningham and Grosh 1978) | Adults | LC50 | 10 d | 0.01 ppm HgCl_2 | 0.037 μM |

The first, second, third, and fourth columns denote, respectively, the species, life stage at exposure to inorganic mercury, the parameter tested, and the duration of exposure. The LC50 mercury doses are listed in the fifth column. Since authors refer to mercury either as HgCl_2 , HgII , or inorganic Hg, all mercury concentrations are expressed in mM or μM in column 6, so the various results can be compared.

areas of the Great Salt Lake varying in salinity would be equally impacted by increasing HgCl_2 levels.

Effect of Hg on Hsp70

No previous work documenting the expression of Hsp70 in *Artemia* in response to metal exposure could be found. In the 7-d exposure, Hsp70 level increased at 10^{-5} and 10^{-6} g.L^{-1} HgCl_2 , two levels that did not produce any mortality or changes in maturation and fertility. Thus, Hsp70 is a potential indicator of stress prior any visible changes in population survival.

The upregulation of Hsp70 might be important in mitigating the cell damages induced by HgCl_2 ; however, the expression of Hsp70 is probably more related to a state of distress rather than to a specific ability to survive HgCl_2 toxicity (Sutton et al., 2002; Franzellitti and Fabbri, 2005). Thus, from our long-term exposure study, we can conclude that 10^{-4} g.L^{-1} (or 0.37 μM) Hg^{++} is, in our study, the lowest concentration affecting *Artemia*'s population size through lower survival, decreased fertility, and delayed maturation. The Great Salt Lake total Hg concentrations average 3 ng.L^{-1} in the 3-m-deep mixed layer (Jones and Wurtsbaugh, 2014), and thus are about 10^5 more dilute than our lowest effect concentration. Such low levels of inorganic mercury are unlikely to affect the Great Salt Lake shrimp; however, Jones and Wurtsbaugh (2014) obtained a 51% mortality rate in *Artemia* growing for 14 d in water from the Great Salt Lake containing 20.62 ng.L^{-1} of total mercury. Their higher mortality rate at such low mercury concentrations could be due to the presence of 3.25 nM methyl mercury (Jones and Wurtsbaugh, 2014), a compound much more toxic than Hg^{++} (Cunningham and Grosh, 1978). In addition, *Artemia* from the Great Salt Lake are likely affected by many other toxins being discharged in the lake from town effluents, local industries, and agricultural activity around its basin. Thus, further studies on the effects of chemicals such as methyl mercury, other metals, pesticides, and petrochemical derivatives would further expand our understanding of the state of health of *Artemia*. Hsp70 is the first biochemical indicator for stress found under laboratory conditions, and its expression in the Great Salt Lake *Artemia* may help us better understand their state of health.

Acknowledgments

The authors are grateful for the support of Dr. John Cavitt and the Weber State University Undergraduate Research Center and for the financial support from WSU Research Scholarship and Professional

Growth Committee nb 213605, which was awarded to N.J.B., and for a grant from the Undergraduate Research Office given to D.I. We would like to thank Drs. John Mull, Jonathan Clark, and Brian Chung for their review of the manuscript and helpful comments. There is no conflict of interest in this work.

Literature cited

Belovsky, G., Stephens, D., Perschon, C., Birdsey, P., Paul, D., Naftz, D., Baskin, R., Larson, C., Mellison, C., Luft, J., Mahon, H., Van Leewen, J., and Allen, D. 2011. The Great Salt Lake Ecosystem (Utah, USA): long term data and a structural equation approach. *Ecosphere* 2(3):art33. DOI 10.1890/ES10-00091.1.

Bhattarcharjee, D., Asem, A., Eimanifar, A., Castro, M.J., and Orozco, D.I. 2013. Effect of inorganic mercury concentration on biometric, survival and LC50 of *Artemia franciscana* Kellogg, 1906 (Crustacea:Anostraca). *Revista Digital del Departamento El Hombre y su Ambiente* 1(3): 6-11.

Brown, B. and Ahsanullah, M. 1971. Effects of heavy metals on mortality and growth. *Marine Pollution Bull.* 2(12): 182-187.

Clarkson, T., 2002. The three modern faces of mercury. *Environ. Health Perspectives* 110: 11-23.

Clegg, J., Jackson, S., Liang, P., and MacRae, T. 1995. Nuclear-cytoplasmic translocations of protein p26 during aerobic-anoxic transitions in embryos of *Artemia franciscana*. *Exp. Cell Res.* 219: 1-7. DOI 10.1006/excr.1995.1197.

Clegg, J., Jackson, S., Van Hoa, N., and Sorgeloos, P. 2000. Thermal resistance, developmental rate and heat shock proteins in *Artemia franciscana*, from San Francisco Bay and southern Vietnam. *J. Exp. Mar. Biol. Ecol.* 252: 85-96. DOI 10.1016/S0022-0981(00)00239-2

Conover, M. and Vest, J. 2009. Concentrations of selenium and mercury in eared grebes (*Podiceps nigricollis*) from Utah's Great Salt Lake, USA. *Environ. Toxicol. Chem.* 28(6):1319-1323. DOI 10.1897/08-494.1.

Corner, E.D.S. and Sparrow, B.W. 1956. The modes of action of toxic agents I. Observations on the poisoning of certain crustaceans by copper and mercury. J. Marine Biol. Assoc. UK. 35(3): 531-548.

Cunningham, P. and Grosch, D. 1978. A comparative study of the effects of mercuric chloride and methyl mercury chloride on reproductive performance in the brine shrimp, *Artemia salina*. Env. Pollut. 15(2): 83-99. DOI 10.1016/0013-9327(78)90098-8.

Davies, K. 1999. The broad spectrum of responses to oxidants in proliferating cells: a new paradigm for oxidative stress. IUBMB Life. 48: 41-47.

Dvorak, P., Benova, K., and Vitek, J. 2012. Alternative Biotest on *Artemia franciscana*. Ecotoxicology. Edited by Ghousia Begum, INTECH, Rijeka, Croatia. p. 51-74.

Environmental Protection Agency, 2009. National primary drinking water regulation. EPA 816-F-09-004 May 2009. <http://water.epa.gov/drink/contaminants/upload/mcl-2.pdf> and <http://water.epa.gov/drink/contaminants/basicinformation/mercury.cfm>

Franzellitti, S., and Fabbri, E. 2005 Differential gene expression in the Mediterranean mussel exposed to various stressors. Biochem. Biophys. Res. Commun. 336(4):1157-1163. DOI 10.1016/j.bbrc.2005.08.244.

Go, E., Pandey, A., and MacRae, T., 1990. Effect of inorganic mercury on the emergence and hatching of the brine shrimp *Artemia franciscana*. Mar. Biol. 107: 93-102. DOI 10.1007/BF01313246

Jones, E.F. and W.A. Wurtsbaugh. 2014. The Great Salt Lake's monimolimnion and its importance for mercury bioaccumulation in brine shrimp (*Artemia franciscana*). Limnol. Oceanogr. 59(1): 141-155.

Kültz, D. 2005. Molecular and evolutionary basis of cellular stress response. Ann. Rev. Physiol. 67: 225-257. DOI 10.1146/annurev.physiol.67.040403.103635.

Leis, M., Manfra, L., Taddia, L., Chicca, M., Trentini, P, and Savorelli F. 2014. A comparative toxicity study between an autochthonous *Artemia* and a non native invasive species. Ecotoxicol. 23:1143–1145

Naftz, D., Angeroth, C., Kenney, T., Waddell, B., Darnall, N., Silva, S., Perschon, C., and Whitehead, J., 2008. Anthropogenic influences on the input and biogeochemical cycling of nutrients and mercury in Great Salt Lake, Utah, USA. Appl. Geochem. DOI 10.1016/j.apgeochem.2008.03.002.

Nunes, B., Carvalho, F., Guilhermino, L., and Van Stappen, G. 2006. Use of the genus *Artemia* in ecotoxicity testing. Environ. Poll. 144(2): 453-462.

Peterson, C., and Gustin, M. 2008. Mercury in the air, water and biota of the Great Salt Lake (Utah, USA). Sci. Total Environ. 405(103):255-268. DOI 10.1016/j.scitotenv.2008.06.046.

Sarabia, R., Torreblanca, J.J., Del Ramo, J.J., Diaz-Mayans, J. 1998. Effects of low mercury concentration exposure on hatching, growth and survival in the *Artemia* strain La Malta parthenogenetic diploid. Comp. Biochem. Physiol. A 120(1): 93-97.

Scholl, D.J. and Ball, R.W. 2005. An evaluation of mercury concentrations in waterfowl from the Great Salt Lake, Utah for 2004 and 2005. Utah Department of Health, Salt Lake City. Retrieved November 4, 2015, from http://waterfowladvisories.utah.gov/docs/GSL_Ducks_2004-2005.pdf.

Sleet, R.B. and Brendel, K. 1985. Homogeneous populations of *Artemia* nauplii and their potential use for in vitro testing in developmental toxicology. Teratog. Carcinog., Mutagen. 5: 41-54.

Sokal, R. and Rohlf, F., 1995. Biometry: The Principles and Practice of Statistics in Biological Research. 3rd Ed. W.H. Freeman and Co., New York. 685-743.

Stohs, S. and Bagchi, D., 1995. Oxidative mechanisms in the toxicity of metal ions. Free Radic. Biol. Med. 18: 321-336.

Sutton, D.J., Tchounwou, P.B., Ninashvili, N., and Shen, E. 2002. Mercury induces cytotoxicity and transcriptionally activates stress genes in human liver carcinoma (HepG₂) cells. Int. J. Mol. Sci. 3(9): 965-984.

Wisely, B. and Blick, R., 1967. Mortality of marine invertebrate larvae in mercury, copper, and zinc solutions. *Aust. J. Mar. Freshwater Res.* 18, 63-72. DOI 10.1071/MF9670063

Wurtsbaugh, D., Gardberg, J., and Izdepski, C. 2011. Biostrome communities and mercury and selenium bioaccumulation in the Great Salt Lake (Utah, USA). *Sci. Total Environ.* 409: 4425-4434. DOI 10.1016/j.scitotenv.2011.07.027.

The PhD Labor Market Imbalance and its Effect on Life Science Departments

**Jonathon C. Marshall,¹ Nile Carrethers,¹ Tyson
Schwab,² Geoff Beck,³ and Leticia Alvarez Gutiérrez²**

*¹Weber State University; ²University of Utah; ³Saint
Louis University*

Abstract

Over the last several decades, an ever-increasing number of life science students have been pursuing graduate school and eventually earning PhDs. This trend, coupled with the flat lining of available tenure-track positions, has created an imbalanced and hypercompetitive job market. Previous researchers have quantified and discussed potential ramifications of this trend. Here, we present the effects this has had on researcher productivity for faculty at undergraduate and PhD-granting universities. To measure and compare research productivity, we calculated mean h-index scores for tenure-track (junior) and tenured (senior) faculty in life science departments from a sample of universities in Utah, Rhode Island, Arkansas, and various high-profile liberal arts colleges. We found small differences between the mean h-index scores for all junior faculty members regardless of institutional level. We also found small differences between junior and senior faculty at undergraduate

universities. However, significant differences in mean h-index scores exist between tenured senior at PhD-granting institutions and all other groups. We discuss the impact of these trends and suggest a possible silver lining to the current situation.

Introduction

Over the last three decades, the number of PhDs awarded has steadily grown each year. For instance, internationally the number of science doctorates earned grew by nearly 40% between 1998 and 2008 (Cyranoski et al. 2011), the life sciences saw a 75% increase in the number of PhDs awarded each year in the U.S. between 1975 and 2000 (Farrell 2001), and more specifically ecology has experienced a threefold increase since 1966 (Hansen et al. 2014). The steady increase in the number of PhDs being granted each year coupled with a nearly flat growth rate for the number of tenure-track jobs available led to an extreme labor market imbalance (Check 2007). The shortage of available faculty positions for PhD-trained scientists is so dire that some are calling for either a massive reform of the PhD system or shutting it down entirely (Taylor 2011). To get a sense of how things have changed, consider that in 1973 within 6 years of earning a PhD in biology, 55% of individuals had secured tenure-track jobs and only 2% were in either non-tenure-track academic positions or postdoctoral positions, whereas in 2006 only 15% had tenure-track jobs and over 18% were in postdoctoral positions or non-tenure-track academic positions (Cyranoski et al. 2011). In the subdiscipline of ecology, the numbers are slightly better, but still fewer than 20% of candidates are obtaining jobs in academia 5 years after graduating with a PhD (Hansen et al. 2014).

This surplus has had a dramatic effect on the academic landscape. One result has been intense competition for job openings for positions at all levels, from community colleges to research universities (Marshall et al. 2009). Applicants with extensive research experience and publication records are now taking positions in high numbers at traditional teaching institutions. To measure one potential effect this has had on the make-up of life science departments within a university and to make comparisons between departments at different institutional levels, we compared mean h-index scores, a metric that estimates research productivity of an individual (Hirsch 2005), for tenure-track and tenured faculty members at a selected number of higher education institutions in Utah, Rhode Island, Arkansas, and top liberal arts colleges. Specifically, we wanted to determine whether differences in

mean h-index scores exist between faculty from four different groups: junior faculty at undergraduate institutions, senior faculty at undergraduate institutions, junior faculty at PhD institutions, and senior faculty at PhD institutions.

Methods

Hirsch (2005) proposed the h-index as a novel way to measure individual scientific output by combining measures for both productivity as well as citation impact of a publication. The h-index can be defined as the number of publications a researcher has with citations greater than or equal to that same number of publications. In practical terms this means, for example, that a scientist that has 10 publications where each publication has been cited at least 10 times would have an h-index score = 10. Another individual might also have 10 papers, but if only five of those papers have been cited five or more times that author would have an h-index score = 5. To extend this measure to an entire department or subset of a department, for instance assistant professors (junior faculty) versus full/associate professors (senior faculty), we calculated a mean h-index score for individuals within that particular group. To calculate h-index scores for individual researchers, we first searched faculty websites at selected universities for lists of faculty publications. This was done over a time period that spanned the years 2009–2011. To ensure more up-to-date lists of publications, we also directly solicited individual publication lists from individual faculty through email. Publication lists were compiled, and h-index scores were calculated by hand for each faculty member by looking up the number of citations for each publication on Google Scholar. Not all faculty members in all departments participated, but enough scores were gathered to be useful in describing an overall trend or pattern. An analysis of variance (ANOVA) was used to compare four designated categories of faculty members: tenure-track/junior faculty at undergraduate institutions (UJF), tenured/senior faculty at undergraduate institutions (USF), tenure-track/junior faculty at graduate (PhD-granting) institutions (GJF), and tenured/senior faculty at graduate (PhD-granting) institutions (GSF). Analysis was done online at <http://turner.faculty.swau.edu/mathematics/math241/materials/anova/>.

Results

Mean h-index scores were quite similar for all assistant professors regardless of university level (Fig. 1). Mean h-index scores were also similar for junior and senior faculty at undergraduate universities and

junior faculty at research/PhD-granting universities. Notably, a significant difference was found between mean h-index scores for senior faculty at research/PhD-granting universities and all other faculty categories (Fig. 1). Not surprisingly senior faculty at these universities had the highest h-index scores, and in most cases the mean h-index scores for senior faculty was nearly double that of junior faculty (Table 1). In contrast, at many undergraduate universities, such as Utah Valley University, Westminster College in Utah, Providence College, and Williams College, the junior faculty had either equal or larger mean h-index scores than senior faculty at their same institution.

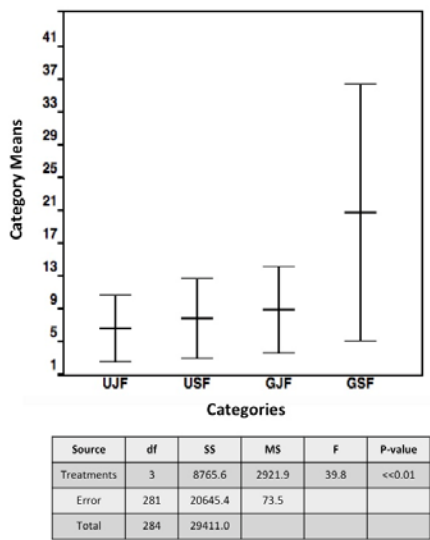


Figure 1. Results of an ANOVA analysis between four designated categories of faculty members: tenure-track/junior faculty at undergraduate institutions (UJF), tenured/senior faculty at undergraduate institutions (USF), tenure-track/junior faculty at graduate (PhD-granting) institutions (GJF), and tenured/senior faculty at graduate (PhD-granting) institutions (GSF). This data set included additional data gathered from the University of Arkansas, Little Rock, Hendrix College, University of Central Arkansas, and the University of the Ozarks. These data are not shown in Table 1. Means and standard deviations are shown on the y-axis and faculty categories shown on the x-axis. Overall mean (\bar{x}_{ave}) = 10.621, specific sample sizes, means, and standard deviations are as follows: UJF (60, 6.700, 4.179); USF (137, 7.876, 4.944); GJF (25, 9.000, 5.385); GSF (63, 20.968, 15.859). The inset table shows other analysis statistics such as degrees of freedom (df), sum of squares (SS), mean square (MS), and F-ratio (F).

| Table 1. Mean h-index scores for life science departments | | | | | |
|--|-------------|-------------|----------|---------------------|-----------|
| Location | Type | Rank | N | Mean h-index | SD |
| Utah | | | | | |
| Univ of Utah | R | S | 31 | 20.2 | 12.9 |
| | | J | 9 | 12.1 | 6.5 |
| Brigham Young Univ | R | S | 17 | 16.8 | 11.2 |
| | | J | 2 | 8 | 5.6 |
| Utah State Univ | R | S | 15 | 10.3 | 5.3 |
| | | J | 8 | 4.1 | 1.8 |
| Weber State Univ | U | S | 10 | 7.7 | 2.7 |
| | | J | 4 | 7 | 3.2 |
| Utah Valley Univ | U | S | 11 | 6.8 | 4.3 |
| | | J | 7 | 8 | 3.2 |
| Southern Utah Univ | U | S | 1 | 6 | N/A |
| | | J | 4 | 4.8 | 2.6 |
| Westminster College | U | S | 4 | 3.75 | 4.9 |
| | | J | 4 | 4 | 1.8 |
| Salt Lake Community College | U | S | 1 | 6 | N/A |
| | | J | 1 | 5 | N/A |
| Rhode Island | | | | | |
| Univ of Rhode Island | R | S | 12 | 15.5 | 6.8 |
| | | J | 4 | 11 | 4.8 |
| Brown Univ | R | S | 8 | 27.75 | 17.65 |
| | | J | 8 | 10.75 | 5.95 |
| Providence College | U | S | 9 | 9 | 6 |
| | | J | 4 | 9 | 2.8 |
| Rhode Island College | U | S | 12 | 6.25 | 3.4 |
| | | J | 5 | 4.4 | 3.4 |
| Bryant Univ | U | S | 2 | 5.72 | 3.3 |
| | | J | 4 | 4.9 | 1.1 |
| Roger Williams Univ | U | S | 6 | 5.5 | 2.07 |
| Salve Regina Univ | U | S | 4 | 8.75 | 1.7 |
| | | J | 1 | 1 | N/A |

| Selected Liberal Arts Colleges | | | | | |
|--------------------------------|---|---|----|------|-----|
| Westminster College, PA | U | S | 2 | 8.6 | 2.3 |
| | | J | 2 | 6.6 | 3.6 |
| Williams College | U | S | 12 | 8.1 | 6.2 |
| | | J | 2 | 9 | 1.4 |
| Middlebury College | U | S | 7 | 9.4 | 5.7 |
| | | J | 2 | 11.5 | 4.9 |
| Bowdoin College | U | S | 10 | 15 | 7.7 |
| | | J | 5 | 7.4 | 2.8 |
| Amherst College | U | S | 7 | 6.6 | 3.5 |
| Pomona College | U | S | 6 | 12.5 | 2.7 |
| Swarthmore College | U | S | 14 | 6.9 | 3 |

U = Undergraduate univ. (life science dept. did not offer Masters or PhD degrees), R = Research/PhD univ., S = senior faculty (full/assoc. professors), J = junior faculty (assist. professors).

Discussion

The academic job market for recent recipients of PhDs continues along a dismal, decades-long, trend of large numbers of extremely qualified applicants with scant opportunities of landing the coveted tenure-track position. Recent publications describe the current situation with colorful titles such as “The Job Market for Academics is Still Terrifying” (Weissmann 2015) and “The PhD Bust: America's Awful Market for Young Scientists—in 7 Charts” (Weissmann 2013) and certainly these publications are not hyperbole. Academia is in a critical and possibly unsustainable situation.

Among such despair, however, there may be some aspects of this trend that may be beneficial, especially for institutions oriented towards undergraduate education. Figure 1 shows that, as illustrated by data gathered during a time period between 2009 and 2011, there were non-significant differences in research productivity and prowess between those junior faculty hired at research institutions ($\bar{x} = 9.00$) and those hired at undergraduate institutions ($\bar{x} = 6.70$). Additionally, the same trend is seen in research productivity between senior faculty at undergraduate institutions ($\bar{x} = 7.88$) and newly hired junior faculty barely starting their careers at undergraduate institutions ($\bar{x} = 6.70$). In real terms what this means is that even though landing a tenure-track position, at all institutional levels, is more challenging than ever before, the cohort that is landing jobs at undergraduate institutions are doing so with a level of scholarly accomplishment never before seen. This

means that undergraduate institutions now have the unprecedented opportunity of developing programs of undergraduate research that may approach levels that have typically been regarded as the province of PhD-granting institutions. To be sure, systemic limitations such as the absence of graduate students, levels of infrastructure, and teaching loads make it extremely challenging for research at undergraduate institutions to be the equal of that of PhD institutions, but we believe a better “middle-ground” may be possible.

Our data show that growth of h-index scores for senior faculty at undergraduate institutions is extremely slow. Newly hired junior faculty generally enter the academy teeming with “research inertia” that does not get fully realized. This paper shows that now, more than ever, it is important that we facilitate a continuation of this research inertia. At a minimum, we believe that undergraduate institutions should initiate or strongly reinforce current programs that grant time-release from some teaching duties during the first year or two of a newly hired faculty members’ load. A heavy teaching load is always taxing on research endeavors and this is especially true during the first few years of a tenure-track job when teaching courses for the first time requires an enormous amount of preparation. Undergraduate universities would also benefit by investing in reasonable start-up packages for new hires so that young investigators can establish research programs that have the potential of reaping decades of grant money as well as pedagogical experiences for students. Lastly, universities, colleges, and departments should lower or completely eliminate the emphasis on service during the tenure-track process. Young researchers’ time and energy are much better spent on writing their first solo grants than in committees discussing the nuances of their university’s policy and procedures manual or the learning outcomes of introductory courses.

To be sure, this study only provides a limited, first look at a trend that may be more widespread. Future studies might involve a more robust quantitative assessment of h-index scores from a larger, more widespread geographic sample. Google Scholar now provides an automatic calculation of a researcher’s h-index that could greatly facilitate the gathering of scores for a much larger data set. Given the importance of this issue for our educational system, studies like these are needed to inform us in making better policy decisions for a higher education system to meet the needs of a 21st century population.

References

Check E. (2007) More biologists but tenure stays static. *Nature* 448: 848-849.

Cyranoski D, Gilbert N, Ledford H, Nayar A, Yahia M. (2011) The PhD factory. *Nature News* 472: 276-279.

Farrell EF. (2001) Number of Ph.D.'s awarded rebound after 1-year dip. *Chron High Educ* Nov. 30, 2001.

Hansen GJA, Sadro S, Baustian MM, Stauffer BA. (2014) Is it time to redefine the “alternative” career path for ecologists? *Limnol Oceanogr Bull* 23: 2-5.

Hirsch JE. (2005) An index to quantify an individual's scientific research output. *Proc Natl Acad Sci USA* 102: 16569-16572.

Marshall JC, Buttars P, Callahan T, Dennehy JJ, Harris DJ, Lunt B, Mika M, and Shupe R. (2009) In the academic job market, will you be competitive? A case study in ecology and evolutionary biology. *Isr J Ecol Evol* 55: 381-392.

Taylor M. (2011) Reform the PhD system or close it down. *Nature News* 472: 261

Weissmann J. (2013) The Ph.D bust: America's awful market for young scientists—in 7 charts. *Atlantic* February 20, 2013.

Weissmann J. (2015) The job market for academics is still terrifying. *Slate* March 23, 2015.

Exploring comparative employee engagement

**Aaron Barros, Sean Costello, Garret Beaman, and
Jonathan H. Westover**

Utah Valley University

Abstract

In an increasingly hypercompetitive and interconnected globalized world and with much of the business world trying to pinpoint reasons for strategic corporate success, the topic of employee engagement is frequently discussed and debated. Employee engagement has repeatedly been shown to directly impact a variety of individual, organizational, and societal outcomes, including employee motivation, satisfaction, and overall performance levels. With the results of a 2013 Gallup Poll on worldwide workforce engagement showing that only 13% of the world's workforce is actively engaged in their work and while the idea of employee disengagement is widespread across industries and companies, there are companies that are taking proactive measures to boost employee engagement. This research uses a case vignette methodology and utilizes the Gallup Q12 (survey questions that identify key drivers of worker engagement) as a framework for understanding comparative workplace engagement, examining Google, Facebook, Twitter, LinkedIn, Bain & Co, and Boston Consulting Group (six of the companies that are repeatedly listed as best places to work according to Forbes, Fortune, Wall Street

Journal, and Glassdoor). The work seeks to find recurring employee engagement trends among these companies (including elements of institutionalized organizational culture, policy, and practice). Conclusions and practical recommendations are provided to help organizational leaders further engage their employees and drive higher levels of individual and organizational performance.

Exploring Comparative Employee Engagement

In a global talent economy, one of the most recurring topics of discussion is employee engagement. All around the world, companies face the ever-complex problem of how to motivate and engage employees in the workplace. In a 2013 Gallup poll, 68.5% of employees reported being either passively or actively disengaged in their current job (Gallup, 2013). While this is the lowest number of disengaged employees since 2000, it is still alarmingly high, given the signs of economic recovery after the great recession. It is estimated that disengagement among employees translates to between \$450 and \$550 billion in lost revenue annually (Gallup, 2013). Companies that ignore aspects of employee engagement are potentially losing revenue and facing diminished profit margins because of costs associated with employee turnover, recruiting, and lost productivity from disengaged workers.

While media coverage often focuses on the failings of companies, some companies (many of which are market leaders in their respective industries) are changing the way leadership approaches employee engagement. In an effort to objectively measure the engagement level of the global workforce, Gallup developed what is referred to as the Q12 survey, which is designed to measure various aspects of daily work life that translate to employee engagement (covering such topics as workplace relationships, career development, resources, communication, and talent utilization). With the topics of this survey in mind, we examined six highly engaged work environments and created six case study vignettes on those companies (each consistently rank among the leading “Best Places to Work”) to identify recurring trends related to topics covered in the Q12 survey. We examined Twitter, Facebook, Google, LinkedIn, Bain & Co., and Boston Consulting Group and extrapolated themes and practical application of how employee engagement can be enhanced in a variety of business settings.

The takeaways from the six case vignettes, along with the following literature overview, demonstrate that companies that address

the various aspects of the Gallup Q12 survey tend to perform better, not just in the competition for top talent in the workforce but financially as well.

Historical Evolution of the Employee Engagement Concept

Researchers have been unable to come to a consensus definition of employee engagement. The term was coined by Kahn in 1990: “Employee Engagement: The harnessing of an organization’s members’ selves to their work roles. In engagement, people employ and express themselves physically, cognitively and emotionally during role performances” (p. 692).

As awareness and understanding of the importance of employee engagement has grown, more and more companies have started to actively monitor their employee engagement levels. In a 2013 Harvard Business Review study, it was found that a highly engaged workforce not only increases productivity and efficiency, but significantly reduces costs from things like employee turnover. Furthermore, there is a significant difference in performance between employees who are engaged and unengaged.

Bhuvanaiah and Raya (2014) define employee engagement as “energy utilized in accomplishing purpose” (p. 61). When an employee becomes engaged, (s)he gains intrinsic motivation, which helps an employee to feel energized to perform tasks. They also state, “... the most frequent dimension used for defining employee engagement is emotional, psychological investment of employee and the right kind of role provided to him or her” (p. 61).

David MacLeod (n.d.) argues that engagement can be defined through three distinct parts: attitude, behavior, and outcome; the attitude of feeling pride and loyalty towards one’s job and employer, the behavior of going above and beyond on a particular task, and outcomes that result in an increase in productivity and innovation and a decrease in conflicts, accidents, sick leaves, and turnover rates. Furthermore, companies with engaged employees produce an environment with trust and respect. Finally, an employee’s emotional commitment is vital, leading to the employee sincerely caring about the company and the work they do.

It is also important to understand how to improve employee engagement. Companies have developed many techniques of which the following are only a few. One recent study demonstrated the importance of communication, mainly face to face, as one of the largest driving forces for increasing employee engagement. Face-to-face

communication is especially important because it has the greatest potential for resolving ambiguity and uncertainty (Mishra et al., 2014). The authors explain, “The front-line supervisor was a key to employees’ organizational engagement. When employees perceive greater support from their supervisors, the employees respond” (Mishra et al., 2014). Furthermore, when the front-line supervisor has consistent face-to-face communication with employees, it helps employees believe they are contributing to the company’s goal because they feel they have a voice and are being heard.

Another technique is giving an employee the ability to express “ideas, feelings, and opinions” in order to produce a direct influence on employee engagement (Yoerger et al., 2015). Moreover, Yoerger et al. (2015) also argue that “employees who contribute their thoughts and ideas in meetings with organizational leaders will also have a desire to engage in their work more fully (i.e., employee engagement)” (p. 6).

While it may not be surprising to some, the statistics regarding workplace satisfaction and engagement have become a great area of concern for both employees and management. The high level of disengaged employees is starting to have a profound impact not only on profits but also on the well-being of those employees who feel disengaged and unhappy in their current jobs. Companies facing low levels of engagement and satisfaction are struggling to attract talent as well as losing out on profits because of lack of employee productivity in the workplace. With all the distressing signals, companies are desperate for answers on how to fix the problem.

Shriar (2014) has some suggestions about how to fix the employee engagement problem. Shriar says that employees appreciate employers who allow them to take on projects that suit their interest and utilize their talents. He also suggests having a customer-oriented culture within the office, which helps in aligning the vision of all the departments of a company and unifying them under a single goal, to meet the needs of the customer. This also helps employees see how their role contributes to the bottom line. Additionally, he suggests that organizational leaders promote cross-functional relationship within the company, thus helping to foster collaboration among different functions and departments. It is also important that employees be encouraged to connect with others in their field, such as human resources or finance, to help them broaden their knowledge and skill base, which can translate into added value for the company. Finally, he emphasizes the importance of getting leadership to not only recognize the engagement problem, but to act on it. As companies invest in their culture and employees, they will start to see the dividends in increased productivity and profits (Shriar, 2014).

A Look into the Top Companies: Six Case Vignettes

We analyzed six companies (Google, Facebook, Twitter, LinkedIn, Bain & Co, and Boston Consulting Group) that are continually rated as best places to work by top business publications, including *Glassdoor*, *Forbes*, *Fortune*, and *The Wall Street Journal*, and appear on multiple 2014 “Top 10 Places to Work” lists. We wrote a short case vignette for each company, comparing its culture, policies, and practices to the research we found to the Gallup Q12 items. Additionally, Appendix 1 contains case questions for each vignette, for use in a school or corporate training setting.

Case Vignette 1: Facebook

Facebook is a social media site that allows users, i.e., customers, to connect with friends and keep up with various aspects of social life via social networking (Reuters, 2014). Facebook was founded by Mark Zuckerberg and four of his Harvard classmates in early 2004. In the first decade of its existence it has become one of the most iconic tech companies in Silicon Valley and averages over 400 million visitors a month (Carlson, 2010).

When it comes to employee engagement, Facebook has put practices into place that model some of the aspects that are covered in the Gallup Q12 questions. Like many tech companies, the culture at Facebook is aimed at promoting creativity and developing new ideas to create new products and improve existing products. In this aspect, Facebook takes great care to recruit people who are passionate about the work they do and does its best to match employees’ passions with their job descriptions. In Facebook boot camp, which individuals in all engineering positions go through, the employees decide which team they would like to be on, thus giving them the autonomy to choose the job they are most passionate about and thus most likely to devote their discretionary effort to. Much autonomy is given to engineers and developers in the way in which they carry out their work (Bort, 2014; Keating, 2012).

The company career page states “We don’t have rules, we have values” (Facebook, 2015). Facebook requires all engineers, no matter what level they are entering at, go through Facebook boot camp, which is a sort of cultural baptism into Facebook (Swift, 2012). This practice can help in regards to the one of the Q12 questions regarding employees’ knowledge of what is expected of them at work. New engineers are educated on every aspect of Facebook culture and code, which helps in aligning vision and purpose within an ever expanding

engineering team (Facebook, 2015; Keating, 2012). Each engineer leaves Facebook boot camp knowing what is expected of them in regard to the type of code that is written and the quality of product they are trying to deliver.

There are many amenities on the Facebook campus, such as a free cafeteria and snacks. Facebook also offers a generous benefits package that covers a wide variety of needs employees may have outside of the workplace. Facebook recently announcing that it includes egg freezing as part of its benefits package to aid female employees who wish to have children in the future but do not want to put their careers on hold to do so (Werntz, 2014). Employee medical, dental, and vision premiums are covered at 100% and those for dependents of employees at around 80%. Facebook also offers a variety of other benefits such as gym membership and a laundry stipend. Whatever the company can do to help employees with those concerns outside of work so that the employee can be focused at work, Facebook will do its best to see that it is done.

As mentioned before, different engineering teams work together at Facebook to create products that connect the world. Teams are small, which lends to a more collaborative environment. Facebook takes measures to ensure it stays away from a hierarchal nature that typical exists in the workforce. Opinions and suggestions at every level are taken into consideration, which helps in making sure each employee feels heard and valued at the organization (Keating, 2012).

As explained in the previous examples, much of Facebook's culture is based around ensuring each of the Q12 questions are answered with a positive response from its employees. Although many may argue that these perks are burdensome to companies, Facebook might beg to differ, with a 63% year-over-year revenue gain in 2013 (Ratner, 2014).

Case Vignette 2: Google

Google was founded in 1998 by Larry Page and Sergey Brin. Over the short period since its founding, it has rapidly grown to be a Fortune 500 company and has been consistently rated as a top 5 company to work for. Google's mission is to organize the world's information and make it universally accessible and useful. It thrives on employee satisfaction and engagement. Google does many things that stimulate engagement and performance in its employees, many of which relate to the Q12 questions.

Google cares for employee well-being

The countless benefits and perks provided to its employees shows that Google want the employees to be healthy and happy. Google provides all meals and snacks along with activities and nap pods to its employees (ChatterJee, 2012). Google also encourages active movements from every person through ergonomically comfortable desks that cycle up and down, allowing employees to stand every once in a while (Breene, 2013). A sample of the other standard perks and benefits can be found in the list below. The idea is the less an employee has to worry about in home and personal life, the more he or she can focus on work.

- Valet parking
- Dental facilities
- Free washer and dryers
- Free food
- Nap pods
- \$500 take-out meal fund for new parents
- 18–22 weeks of paid leave for new parents
- 5 years and up to \$150,000 reimbursements for higher education
- Unlimited sick leave
- Community service opportunities

“You are noticed” culture

Google also values employee input. Every Friday, Google holds a meeting with drinks and food at which employees can make suggestions to the management and executive groups (Crowley, 2013). These employees also receive hefty bonuses as recognition for great performance. Sometimes they get up to 10% bonuses for their performance (Blodget, 2010). Google also provides many activities for employees not only to relieve stress but also to build relationships among coworkers. These relationships help employees feel like they belong in such a large company.

Personal learning and growth

Being one of the top companies in the world enables Google to hire the best of the best. This in turn creates an environment that demands quality and performance, thus creating an environment where employees push themselves to grow and develop in order to progress in the company.

Being a part of something bigger

Employees are given a chance to learn, grow, and feel like what they are doing is important through the projects they work on. For example, each employee has the opportunity to work on “interesting projects that are changing the world” giving them a purpose to fuel all their hard work (Glassdoor.com, n.d.). They are also allowed to use 20% of their paid time to work on any project they would like (Loosvelt, 2013). It could be a personal project if they’d like. This allows them to use/develop their imagination and creativity, which is very important for Google employees.

All of these elements give Google employees the tools to succeed. Good health, strong voice, and a meaningful purpose are all important tools that any human needs to make a difference and do their job in a company that makes a difference in the world.

Case Vignette 3: Twitter

Twitter's mission is to give everyone the power to create and share ideas and information instantly, without barriers. Twitter is microblogging, sending out daily short-burst messages. It's about discovering interesting people around the world (Gil, 2012).

Twitter's foundation for success starts with its management and leadership teams of the company. CEO Dick Costolo personally runs management training sessions at least once a quarter. He believes in moving away from computers and slides to instruct; rather, he uses stories, personal leadership ideas, and role playing to instruct and lead the managers to success (Kruse, 2012). This allows every employee to know exactly what is expected of them and to learn and grow directly from a trickle-down effect started by Costolo.

Costolo believes, and in his management training sessions stresses, “the importance of defining what success looks like in each role, setting the direction, and just as critically, giving feedback in an open, authentic and fearless way.” (Kruse, 2012). Unfiltered, direct feedback helps employees grow and further apply themselves. Twice a year, there is an official performance review process, and quarterly learning labs are taught to help employees learn to both give and receive back. Employees also participate in another twice-a-year survey of approximately 15 questions. In this survey, employees answer open-ended questions that allow input for direction and improvement of the company.

For continuing development of its employees, Twitter developed five core skills towards which all employees work: communication, development, direction, change, and collaboration (Kruse, 2012).

Having defined skills to work towards allows Twitter employees to know what is most important to the progress and development of the company.

The mindset of Twitter as a whole is “your work will be immediately felt by millions of people around the globe” (Glassdoor, 2014). This mindset helps employees to stay motivated and to feel as though they are making an immediate difference in doing what they do best—their job. Twitter reports the employees as saying “the most important benefit we [Twitter] offer is the work itself—the chance to solve interesting problems while having a positive impact on the world” (Glassdoor, 2014).

Twitter was started only eight years ago and has had tremendous growth. Twitter hires employees with the brightest minds, and 50% of the company is comprised of engineers to further their global connecting mindset (Twitter, 2014). Employees have been known to talk about all the “smart people” they work with and have been known to say “I joined Twitter, and I joined a family” (Glassdoor, 2014). The company places people into work groups that allow the brightest minds to collaborate on something they are passionate about, while at the same time developing close, lasting friendships.

Twitter's overarching goal is to create and share ideas instantly on a global scale. The company has created a successful culture to accomplish that goal. They have the right people and the right tools needed to accomplish this goal.

Case Vignette 4: Boston Consulting Group

Boston Consulting Group (BCG)'s mission is to seek to be agents of change—for their clients, their people, and society broadly. BCG is a private consulting firm for branding and marketing, corporate finance, globalization, business strategy, leadership development, and information technology (Glassdoor, 2014).

BCG's foundation for success starts with its employees. CEO Rich Lesser said, “Attracting top talent and maintaining an environment in which employees can rapidly develop have been key to our success and our ability to deliver enormous value to clients” (Yahoo! Finance, 2012). BCG does this by offering great benefits and training to its employees. BCG pays 100% of employees' health-care premiums, offers fully paid sabbaticals, and is hailed for having “gay-friendly benefits” and a “gay-friendly policy.” BCG is also one of the top employers for annual pay for salaried employees (Yahoo! Finance, 2012).

BCG is known for having a high workload, high success, and high impact. A lot is demanded of the employees. To help accommodate this demand, one employee said, “Training and growth opportunities [are] available to even the youngest employee—impossible to surpass this experience for a first job, and I feel like it will pay dividends for the rest of my career” (vault.com, 2014). Because the employees are the center of its success, BCG emphasizes work–life balance. If an employee seems to be overworked because of workload or just working too much by choice, the company issues “red zone” reports to flag employees who’ve put in too many hours on a project. BCG keeps a close eye on employee engagement to ensure workers don’t burn out (Breslin, 2013).

One of the greatest successes of BCG’s employees comes from their dedication to leadership training. Barber (2012) talks about the leadership development:

“BCG believes there is always room for improvement and provides employees every tool imaginable to see their potential realized. Employees have access to workshops, online training tools, mentoring and apprenticeship programs, career development programs, a clear career path and support system for professional development and more”

This allows employees to always be developing their skills while having people check on their progress often. Employees have a sense of ownership in the company. BCG strives to have a sharp focus and a positive culture. One employee said:

“There’s just a true sense of partnership that permeates the whole place. It’s about the team, and ‘we succeed together.’ It just feels like a very supportive place to work. It’s not perfect, but I think everybody understands that if something is not going well, they can raise their hands.” (Glassdoor, 2014)

The goals and company culture at BCG drive this company to success. The company is always open for suggestions of improvement. The company has a “feedback-heavy culture” (vault.com, 2014) to keep everyone as positive and productive as possible. Working at BCG prepares employees and provides them opportunities for growth in the world.

Case Vignette 5: LinkedIn

LinkedIn is a social networking company that provides employment networking opportunities for those involved. It was founded by Reid Hoffman in 2002 and since has grown to be a networking powerhouse. On top of this, LinkedIn is also considered one of the best companies to work for according to the *Forbes* rankings. Because of this, we have decided to look further into what this company does to get the employees involved and excited about work.

Benefits

LinkedIn has found a balance between “‘big company’ benefits and ‘small company’ mobility” (Glassdoor, n.d.). They do this by providing all of the larger company benefits like full insurance coverage, retirement plans (401K), and stock purchase, while at the same time allowing employees the freedom of mobility and flexible schedule. They also provide benefits such as free food, nice offices, traveling opportunities, and many other perks (Glassdoor, n.d.).

Leadership Style

The leadership style pushes the value of putting the customer and employees first. In fact, in their very culture they stress the importance of transforming three things: yourself, your company, and your community (Glassdoor, n.d.). LinkedIn management style strives to bring out the best in its customers and employees. LinkedIn tries to match a person’s strengths with an activity that fits them and aims to match its leadership style with its business strategy. What LinkedIn does inside the business is the same thing it does for the community.

Opportunity

There is always a chance to learn in this company. It has a culture of continuous learning. In fact, one employee even said he was “a little intimidated at first, how much learning was constantly taking place” (Glassdoor, n.d.). However, this quickly subsided to a feeling of growth and satisfaction, which many employees reportedly love about LinkedIn.

Sense of fulfillment

Employees at LinkedIn see the impact that they have on society through numbers and reviews. They are motivated in “Executing on a bold vision like creating economic opportunity for 3.3 billion people

around the world” (Meister, n.d.). In fact, “40% of LinkedIn users make over 100 grand a year” (Baer, 2012). Providing users with an opportunity to provide for themselves and others is a great service to the community. Because of this, employees can sleep easy knowing that their company and job is making the world a better place. However, LinkedIn isn’t satisfied with just that. LinkedIn also does a great job in giving its employees opportunities to make a difference in the community. For example, “One Friday each month, LinkedIn’s employees participate ‘InDay.’ InDay’s purpose is to give back to the community through employee volunteerism and resources” (Forman-Ortiz, 2013). Each of these Fridays allows the different departments a chance to meet together and interact with each other for a common cause. On top of this, LinkedIn provides employees Transformation Grants (LinkedIn, n.d.), which fund community service activities that they decide to do.

A sense of fulfillment, opportunities, management style, and benefits are all important tools LinkedIn uses to build a successful and well-cultured company.

Case Vignette 6: Bain and Co.

Bain & Co. is a management consulting firm headquartered in Boston, Massachusetts. Consultants at Bain work with clients in a variety of different aspects of business such as operations, technology, and organization. Founded by former employees of the Boston Consulting Group, their list of clients has grown to include a majority of Global 500 members (Bain & Co., n.d.).

In a 2012 glassdoor.com survey, Bain & Co. was ranked as the best place to work in the U.S., beating out 65,000 other companies considered for the award. Among the possible reasons for the high satisfaction rating is the amount of time and resources Bain & Co. dedicated to recruiting and talent selection. The interview process at Bain is known to be among the most intense in the business world (Ahmed, 2013). With such great efforts put into the selection process, it could be suggested that Bain & Co. has a better understanding of the current talent pool and is better able to select those who will fit within the high-paced culture of Bain & Co.

As one observes the workforce of Bain & Co., it is evident that a high level of engagement exists among their employees. Many employees comment on how they enjoying the fast-paced and challenging work (Ahmed, 2013). This certainly is a positive sign of employee engagement, especially among those that thrive off challenging work and utilizing their skill set to produce their best work.

Given the vast amount of experience employees of Bain & Co. gain across numerous industries, employees are also able to develop vast skill sets and gain industry knowledge that few are privy to (Bain, n.d.).

Another aspect of employee engagement for which Bain & Co. is known is the focus on employee success. Bain & Co. emphasizes collaborative teamwork among its employees, which no doubt helps to foster a culture of kinship and support. Many Bain employees have commented on how supportive the environment is in which they work, referring to their co-workers as “Bainees” (clearlink.com, 2012). As strong culture of camaraderie prevails, there is a positive correlation in satisfaction of workplace relationships. Bain & Co. invests heavily in employee training and development, and many employees attribute their success to the training they receive. One could assume that this type of culture helps employees feel that Bain & Co. is invested in employee development and values employee growth on a personal and professional level.

In regards to benefits provided to employees, Bain & Co. had rating of 4.7 out of 5 on glassdoor.com. Some of the perks outside of the traditional insurance coverage included generous contributions to employee retirement funds as well as maternity/ paternity leave and adoption assistance. They also offer 3 weeks of vacation during the calendar year as well as tuition assistance (Glassdoor.com, 2015). Overall, the benefits package offered by Bain & Co. is regarded as very generous.

In conclusion, Bain & Co. seems to have created a culture of consistency and has invested heavily in creating a culture of values that drive quality performance. This culture and environment of challenging, fast-paced work attracts some of the brightest from around the world looking for that unique environment. Bain & Co. remains a staple among Fortune 500 companies and continues to make a global impact in helping business drive growth. It is their commitment to employee development and teamwork that makes their success possible.

Conclusions and Recommendations

Following our analysis of six top places to work, we found repeated engagement themes present in the each organization’s structure, culture, policies, and practices, including:

Each company has a focused belief that what they are doing makes a difference in the world and that they make a real difference every day. This flows into the employees’ work, which helps

employees feel like they are doing something important and that they are valued.

Each company has put things into place so that while employees are at work, they can focus on work. Some examples of these elements include free food, valet parking, dry cleaning, nap pods, health centers, and massage therapists.

Each company always has its focus on the employees. They focus on employee growth and direct, unfiltered feedback. This allows the employees to know what they need to work on to improve. These companies have a strong focus on communication and knowing each employee, which allows managers to know where and how to help employees. An example of this comes from Twitter CEO Dick Costolo, who personally ran quarterly training meetings with all managers. This flattens the corporate ladder.

Each company provides a way for individual employees to provide feedback and ideas on the direction of the company. This increases employee buy-in and dedication. Doing this also helps employees to feel like they have a direct say in what they company does and helps them to feel heard.

Each of the companies examined in this paper has been able to create an environment where employees are able to grow personally and contribute to the growth of their organizations. With these takeaways, we recommend four simple steps to increase employee engagement in any company:

- Have a mission statement focused on the positive difference the organization is making in the world. Help the employees feel the connection between their personal job and the mission of the company.
- Put things in place so that while at work the employees can focus on work and not be stressed about outside personal matters.
- Always keep the main focus on the growth of the employees through direct face-to-face feedback.
- Come up with a way for employees to provide feedback and suggestions on the direction of the company.

References

Ahmed, M. (2013, February 21). Inside View: Bain & Company. Retrieved December 2, 2014, from <http://www.businessbecause.com/news/inside-view-top-jobs/1866/inside-view-bain-jobs-russ-hagey->

Baer, D. (2014, December 3). 40% Of LinkedIn Users Earn More Than \$100,000 A Year. Retrieved January 6, 2015, from <http://www.businessinsider.com/linkedin-user-wealth-2014-12>.

Bain & Co. (n.d.). About Bain & Company. Retrieved January 15, 2015, from <http://www.bain.com/about/index.aspx>.

Barber, T. (2012, January 23). Best Practices from Best Companies, Part 2 of 3: Leadership Development. Retrieved December 9, 2014, from <http://www.greatplacetowork.com/publications-and-events/blogs-and-news/763-best-practices-from-the-2012-best-companies-part-2-of-3-leadership-development>.

Bhuvanaiah, T., & Raya, R. P. (2014). Employee Engagement: Key to Organizational Success. *SCMS Journal of Indian Management*, 11(4), 61-71.

Blodget, H. (2010, November 9). Google Gives All Employees Surprise \$1,000 Cash Bonus And 10% Raise. Retrieved October 28, 2014, from <http://www.businessinsider.com/google-bonus-and-raise-2010-11>.

Bort, J. (2014, August 22). The 25 Most Enjoyable Companies To Work For. Retrieved October 28, 2015, from <http://www.businessinsider.com/25-best-corporate-cultures-2014-8?op=1>.

Breene, S. (2013, May 28). Why Are Google Employees So Damn Happy? Retrieved October 28, 2014, from <http://greatist.com/happiness/healthy-companies-google>.

Breslin, M.M. (2013, February 20). Part of Boston Consulting Group's Success Comes From Looking Out for Its Workers. Retrieved December 9, 2014, from <http://www.workforce.com/articles/part-of-boston-consulting-group-s-success-comes-from-looking-out-for-its-workers>.

Carlson, N. (2010, March 5). At Last—The Full Story Of How Facebook Was Founded. Retrieved October 28, 2014, from <http://www.businessinsider.com/how-facebook-was-founded-2010-3?op=1>.

ChatterJee, S. (2012, January 20). Top 5 Reasons Why Google is the Best Company to Work For. Retrieved October 28, 2014, from

<http://www.ibtimes.com/top-5-reasons-why-google-best-company-work-553844>.

Clearlink Marketing & Sales. (2012, February 27). Retrieved December 9, 2014, from <http://www.clearlink.com/uncategorized/culture-video-bain-company-facebook.html>.

Crowley, M. (2013, March 23). Not A Happy Accident: How Google Deliberately Designs Workplace Satisfaction. Retrieved October 21, 2014, from <http://www.fastcompany.com/3007268/where-are-they-now/not-happy-accident-how-google-deliberately-designs-workplace-satisfaction>.

Facebook. (n.d.). Facebook Careers. Retrieved January 8, 2015, from <https://www.facebook.com/careers>.

Forman-Ortiz, L. (2013). Top 10 Socially Responsible Companies | SmartRecruiters Blog. Retrieved January 6, 2015, from <http://www.smartrecruiters.com/blog/top-10-corporate-social-responsibility-initiatives/>.

Gallup Organization. (2013). State of Global Workforce. Retrieved September 15, 2014, from http://ihrim.org/Pubonline/Wire/Dec13/GlobalWorkplaceReport_2013.pdf.

Gil, P. (2012, July 1). What's Twitter and What Does Tweeting Mean? Retrieved October 28, 2014, from <http://netforbeginners.about.com/od/internet101/f/What-Exactly-Is-Twitter.htm>.

Glassdoor. Bain & Company Employee Benefits and Perks. (n.d.). Retrieved January 15, 2015, from http://www.glassdoor.com/Benefits/Bain-and-Company-US-Benefits-EI_IE3752.0,16_IL.17,19_IN1.htm.

Glassdoor. Google Reviews. (n.d.) Retrieved October 20, 2014, from <http://www.glassdoor.com/Reviews/Google-Reviews-E9079.htm>.

Glassdoor. LinkedIn Reviews. (n.d.) Retrieved October 28, 2014, from <http://www.glassdoor.com/Reviews/LinkedIn-Reviews-E34865.htm>.

Glassdoor. Twitter Reviews. (n.d.). Retrieved October 28, 2014, from http://www.glassdoor.com/Overview/Working-at-Twitter-EI_IE100569.11,18.htm.

Glassdoor. (2014, January 1). Working at Boston Consulting Group. Retrieved December 9, 2014, from http://www.glassdoor.com/Overview/Working-at-Boston-Consulting-Group-EI_IE3879.11,34.htm

Harvard Business Review Analytic Services. (2013). The Impact of Employee Engagement on Performance. Retrieved March 1, 2015, from https://hbr.org/resources/pdfs/comm/achievers/hbr_achievers_report_sep13.pdf.

Kahn, W.A. (1990, December 1). "Psychological Conditions of Personal Engagement and Disengagement at Work." *Academy of Management Journal*, 33(4), 692-724.

Keating, C. (2012, May 16). Inside Facebook. Retrieved January 8, 2015, from <http://fortune.com/2012/05/16/inside-facebook-2/>.

Kruse, K. (2012, October 23). 4 Ways Twitter Keeps Its Workforce Inspired and Engaged. Retrieved October 28, 2014, from <http://www.forbes.com/sites/kevinkruse/2012/10/23/twitter-employee-engagement/>.

LinkedIn. (n.d.). Careers & Employment. Retrieved January 6, 2015, from <https://www.linkedin.com/company/linkedin/careers>.

Loosvelt, D. (2013, March 26). Why Google's a Great Place to Work and Your Company Isn't. Retrieved October 28, 2014, from <http://www.vault.com/blog/salary-and-benefits/why-googles-a-great-place-to-work-and-your-company-isnt/>.

McLeod, David. (n.d.). What is Employee Engagement? Retrieved October 14, 2014, from <http://www.engageforsuccess.org/about/what-is-employee-engagement/>.

Meister, J. (n.d.). 10 Leadership Lessons From Jeff Weiner, CEO of LinkedIn. Retrieved January 6, 2015, from <http://www.forbes.com/sites/jeannemeister/2012/09/10/10-leadership-lessons-from-jeff-weiner-ceo-of-linkedin/>.

Mishra, K., Boynton, L., & Mishra, A. (2014). Driving Employee Engagement The Expanded Role of Internal Communications. *International Journal of Business Communication*, 51(2), 183-202.

Reuters. Profile: Facebook Inc (FB.O). (n.d.). Retrieved October 28, 2014, from <http://in.reuters.com/finance/stocks/companyProfile?symbol=FB.O>.

Ratner, J. (2014, January 30). Facebook Inc stock is soaring: Here's why. Retrieved January 10, 2015, from http://business.financialpost.com/investing/facebook-inc-shares-thursday-2014?__lsa=1867-aefe.

Shriar, J. (2014, November 21). 13 Scary Statistics on Employee Engagement. Switch & Shift. Retrieved January 15, 2015, from <http://switchandshift.com/13-scary-statistics-on-employee-engagement>.

Swift, M. (2012, April 18). A look inside Facebook's 'Bootcamp' for new employees. Toronto Star. Retrieved January 8, 2015, from http://www.thestar.com/business/2012/04/18/a_look_inside_facebooks_bootcamp_for_new_employees.html.

Twitter. (2014, January 1). About Twitter, Inc. Retrieved October 29, 2014, from <https://about.twitter.com/company>.

Vault (n.d.). The Boston Consulting Group. Retrieved November 1, 2014, from <http://www.vault.com/company-profiles/management-strategy/the-boston-consulting-group,-inc/company-overview.aspx>.

Wertz, K. (2014, October 21). Business benefits: From Facebook's egg freezing to Virgin unlimited holidays. The Guardian. Retrieved January 8, 2015, from <http://www.theguardian.com/sustainable-business/2014/oct/21/facebook-apple-egg-freezing-virgin-unlimited-holidays-business-benefits>.

Yahoo! Finance. (2012, January 19). The Boston Consulting Group Ranks No. 2 Among FORTUNE's Best Companies to Work For... Again. Retrieved December 9, 2014, from <http://finance.yahoo.com/news/boston-consulting-group-ranks-no-170800395.html>.

Yoerger, M., Crowe, J., & Allen, J. A. (2015). Participate or else!: The effect of participation in decision-making in meetings on employee engagement. *Consulting Psychology Journal: Practice and Research*, 67(1), 65.

Appendix 1: Questions for Case Vignettes

Facebook Case Questions:

- Is the culture at Facebook only conducive to one particular type of employee or worker? If so, what type of employee would prefer the culture promoted at Facebook?
- Facebook tries to instill a culture of values rather than rules. Can this philosophy apply to other industries other than the technology sector?
- What role do workplace amenities such as free meals and game rooms play in employee engagement? Do they help workplace satisfaction? Why or why not?

Google Case Questions:

- How does Google show its employees it cares?
- What is something you can think of that Google can do to get the employees engaged that has not been mentioned in this article?
- Which of these areas listed do you think is most helpful in getting the employees engaged?

Twitter Case Questions:

1. Twitter has grown at a rapid rate since starting in 2006. What are some of the things the company has done to facilitate and feed this growth?
2. What does it do for a company when the CEO has direct contact and training with frontline managers?
3. Why is it important to feel that your work makes a difference?
4. How does “unfiltered, direct feedback” help companies and employees grow? What are some ways to give good, useful feedback?

Boston Consulting Group Case Questions:

1. Why is it so important for BCG to attract top talent? What strategies do they employ to attract that top talent?
2. What are some other ideas BCG could use to alleviate some of the high pressure stress on their employees, while still maintaining their high output performance?
3. With the younger generations coming to be the new leaders at BCG, will the company have to change its culture to fit the new style of the upcoming generations? Why or why not?

LinkedIn Case Questions:

1. Why do you think LinkedIn gives the benefits they do rather than just a high salary?
2. What area could LinkedIn focus on to increase employee engagement and satisfaction? Within this area, give a few suggestions on how they could improve.
3. Have you noticed any of these traits in companies you (or someone close to you) have worked for? If so, how did you feel that affected you and your satisfaction/motivation?

Bain & Co. Case Questions:

1. How does a company like Bain & Co. maintain consistency in its culture while being a global company?
2. What role does talent selection play in the employee engagement? Is it the most important aspect of their high engagement?
3. What challenges may face Bain & Co. as the new generation of millennials enters the workforce?

Accounting for Virtual Currency Transactions

Jennifer Harrison and Ronald Mano

Westminster College

Abstract

Bitcoin is a mysterious “currency” that was developed by a person identified as Satoshi Nakamoto but no one seems to know whether such a person even exists. Individuals can obtain bitcoin by “mining” for them on their computers solving complex mathematical formulas that become increasing more complex as more and more bitcoins are mined. As accountants, of particular interest to the authors of this paper is the accounting for bitcoin transactions. Apparently, the Sacramento Kings of the National Basketball Association and Overstock.com, a Utah company, along with many other smaller establishments have begun accepting bitcoin as payment. The questions of how to account for the “currency” relates to whether it is even a currency at all. Perhaps the accounting ought to be related more as barter or as foreign currency transactions than as ordinary sales.

Introduction

Daily headlines, from both online sources and well-established journals, tell of the quick evolution of virtual currencies—the most

widely known of which is the bitcoin. Just during 2013, these headlines have changed in nature from articles trying to explain what virtual currencies are (Kleinman 2014), to articles heralding the newest companies to accept bitcoin (Love 2014), to actions by governmental agencies to regulate the industry (Sidel 2013). Always of interest has been the value of the bitcoin—which has grown from an initial value of a few cents to a high of over \$1,000 per bitcoin (Samuelson 2014).

Current news of bitcoin is focused on the shutdown of the largest exchange, Mt. Gox, due to possible computer glitches that allowed manipulation of transactions. Mt. Gox's website says it all: "In light of recent news reports and the potential repercussions on Mt. Gox's operations and the market, a decision was taken to close all transactions for the time being in order to protect the site and our users. We will be closely monitoring the situation and will react accordingly." (Mt. Gox 2014).

Genesis of Bitcoin

A quick reading of the original white paper written by Satoshi Nakamoto provides insight into the original, simple purpose of the bitcoin virtual currency. The purpose is to provide a method of payment that does not rely on the monolithic and cumbersome financial industry—a method of electronic payment from one person to another without the need of a third party to verify the validity of the payment.

Nakamoto's elegant solution is a peer-to-peer system that not only generates the currency itself, but also provides the validation needed for each transaction (Nakamoto 2014). This validation purportedly removes the ability to double-spend any one bitcoin (or portion of a bitcoin). From this proposal, written in 2008, has sprung a small industry of companies that:

- provide the computer power to generate the currency and provide transaction validation;
- offer virtual wallet capabilities to individual users;
- supply various merchant services, such as integration into online shopping carts and automatic exchange of bitcoin to government-backed currency, to companies accepting bitcoin;
- furnish bitcoin exchanges.

The question is; will bitcoin or other virtual currencies continue? Is it a fad or the beginning of a new type of currency? If the virtual currency idea does survive, there are many aspects from which to study virtual currencies—for example; economic, political/regulatory, and technological. The remainder of this discussion will focus on possible

accounting methods for recording sales and purchase transactions using bitcoin or other virtual currencies.

Accounting for Virtual Currencies

In researching this topic, two statements found within bitcoin literature solidified the idea that guidance—from the accounting profession—should be provided to businesses utilizing virtual currencies.

One statement, found at Bitcoin.it, declares “When a customer makes a payment, you might simply issue a credit to their account. Ideally, you want to enter it in a way that suggests you received a payment. You could consider entering it as a “discount,” but you may want to consider whether this inappropriately disguises the nature of the transaction. If on the other hand, you’re giving “discounts” for bitcoins, but then you are selling the bitcoins for currency and then counting that as income, then chances are good that your calculation of income is making up for it. *Ask your accountant.*”

Another statement also found at the above website states, “As for how to decide what a bitcoin transaction is worth...the IRS, as far as we know, has never issued a guide mentioning how to value bitcoin transactions. But they probably have rules and guidelines on how to value transactions made in foreign currency or ‘cash equivalents. We imagine the accounting would be similar.”¹

“With Bitcoins, there’s likely to be some difference between the value of BTC [Bitcoin] when you received them as payment, versus when you go to exchange them for another currency like USD, should you decide to do so. This scenario, likewise, would be no different if you accepted foreign currency or gold as payment. Under some scenarios, it might make sense to book the dollar value of BTC income as it is received, and then to book any difference incurred when it is exchanged for fiat currency. Under others, it might make sense to book the whole thing at the time of exchange.

“Perhaps you might talk to your accountant. You don’t need to get into a discussion with your accountant about block chains and private keys or the philosophy behind a decentralized currency. By comparing the fundamentals of Bitcoins to accounting concepts already well understood by the public, you can probably get all the answers you

¹ In March 2014, the IRS did publish guidance announcing that virtual currency—for tax purposes—will be treated as property and not currency.

need. What would you ask your accountant if you decided that you wanted to accept *Berkshire Bucks* or 1-ounce gold coins as payment?" (Bitcoin.it 2014).

Accountants turn to the Financial Accounting Standards Board (FASB) for authoritative guidance on accounting treatment. As virtual currencies are relatively new, any guidance should be found in either the FASB Accounting Standards Codification (ASC) Updates or as an agenda item for the Emerging Issues Task Force (EITF).

The only recent ASC Updates possibly related to the issue of virtual currencies or virtual currency accounting are:

- Update No. 2013-05—*Foreign Currency Matters (Topic 830)*: Parent's Accounting for the Cumulative Translation Adjustment upon Derecognition of Certain Subsidiaries or Groups of Assets within a Foreign Entity or of an Investment in a Foreign Entity (a consensus of the FASB Emerging Issues Task Force)
- Update No. 2010-19—*Foreign Currency (Topic 830)*: Foreign Currency Issues: Multiple Foreign Currency Exchange Rates (SEC Update) (Financial Standards Accounting Board 2014).

Neither of these updates addresses virtual currencies.

A review of the FASB Emerging Issues Task Force list of current issues as of the November 14, 2013, meeting (Financial Standards Accounting Board 2014) shows that the topic of virtual currency is not on the FASB radar.

With no authoritative guidance for accountants relating to virtual currencies, the only alternative left is to identify and adapt existing accounting standards. From an accountant's perspective, how should a transaction involving virtual currencies be accounted for? After review and analysis, two alternatives appear to be promising: Non-monetary Exchanges and Foreign Currency Transactions.

Non-monetary Exchange

The view that virtual currency transactions should be accounted for as non-monetary exchanges hinges on the argument that the virtual currency is similar to a barter credit.² Given this opinion, ASC 845

² A barter credit is a "currency" that is only recognized by, and can only be used within, a barter group.

Non-monetary Transactions provides guidance on handling transactions involving virtual currency.

Non-monetary exchanges, in general, include an “Exchange of product held for sale in the ordinary course of business (inventory) for other property as a means of selling the product to a customer.” [ASC 845-10-05-06]. More specifically to barter transactions per the ASC “In a barter transaction involving barter credits, an entity enters into a transaction to exchange a nonmonetary asset (for example, inventory) for barter credits. These transactions may occur directly between principals to the transaction or include a third party whose business is to facilitate those types of exchanges (for example, a barter entity).” [ASC 845-10-05-10].

Under ASC 845-10-30-01, non-monetary exchanges are based on the fair value of the assets (or services) involved. In general, the fair value of the assets given is used to measure the value of the transaction with any difference between fair value and carrying value being recognized as a gain or loss. However, if the fair value of the asset received is considered more reliable, then that is used to measure the value of the transaction.

If a virtual currency transaction is to be viewed as a non-monetary exchange, one of the contributing arguments would be the lack of reliable value of the currency (similar to a barter credit). Thus, in a typical transaction in which inventory is sold to a customer, the likely value to be used would be the fair value of the inventory. This is consistent with ASC 845-10-30-17, which states, “In reporting the exchange of a nonmonetary asset for barter credits, it shall be presumed that the fair value of the nonmonetary asset exchanged is more clearly evident than the fair value of the barter credits received and that the barter credits shall be reported at the fair value of the nonmonetary asset exchanged.”

The existence of quoted market values for barter credits, however, does not disqualify a transaction from being considered a non-monetary exchange. Per ASC 845-10-30-18, “However, that presumption might be overcome if an entity can convert the barter credits into cash in the near term, as evidenced by a historical practice of converting barter credits into cash shortly after receipt, or if independent quoted market prices exist for items to be received upon exchange of the barter credits. It also shall be presumed that the fair value of the nonmonetary asset does not exceed its carrying amount unless there is persuasive evidence supporting a higher value.”

For a bitcoin, the infrastructure via merchant services, to trade the virtual currency for dollars is in place. Additionally, several exchanges providing current market prices are available.

Under the non-monetary exchange theory of accounting for virtual currency transactions, a company selling/trading a computer with a fair value of \$50 and a book value of \$200 (\$1,000 original cost and \$800 accumulated depreciation) for bitcoin would book the following entry—assuming the transaction had commercial substance.

| | |
|--------------------------|---------|
| Bitcoin | \$50 |
| Accumulated Depreciation | \$800 |
| Loss of Sale of Computer | \$150 |
| Computer | \$1,000 |

The company uses the fair value of the asset given up to value the asset received and recognizes a loss between the book value and fair value of the asset given up.

Foreign Currency Transaction

ASC 830, Foreign Currency Matters, provides accounting guidance for the alternative method under consideration herein for transactions using Bitcoin. The assumption made, if this view is taken, is that the virtual currency is considered a form of currency and a foreign currency to the entity entering a transaction.

Per ASC305-10-20 (Glossary), cash is defined in part as “not only currency on hand but demand deposits with banks or other financial institutions. Cash also includes other kinds of accounts that have the general characteristics of demand deposits in that the customer may deposit additional funds at any time and also effectively may withdraw funds at any time without prior notice or penalty.” A strict interpretation of this definition could exclude virtual currencies from being considered cash as most existing forms are not associated with a financial institution and the effective withdrawal of funds may not always be possible; however, the invention of virtual currencies as stated previously is to provide a method of payment that does not rely on a financial industry—a method of electronic payment from one person to another without the need of a third party. Likewise, from a practical perspective, if individuals accept a virtual currency as means of payment, it is a currency. Similar to government-issued coin and currency, virtual currencies have value primarily as a means of transacting business (and secondarily as an investment).

Given that virtual currency is considered a type a currency, it would then have to pass another test to determine if it is a functional or foreign currency. Per ASC 830-10-20 (Glossary), a foreign currency is defined as “a currency other than the functional currency of the entity

being referred to.” The functional currency referred to within this definition is simply the currency in which the company typically transacts business and presents its financial statements. It “is the currency of the primary economic environment in which the entity operates; normally the environment in which an entity primarily generates and expends cash.” [ASC 830-10-45-02]. Presently, it is unlikely that any company can claim that virtual currency is its functional currency as financial statements are not presented in a virtual currency and virtual currency is not pervasive enough for any company to claim it as being the currency in which it primarily generates and expends cash. Thus, virtual currency is a foreign currency.

Accepting that virtual currency is a foreign currency, use of the foreign currency method requires a known exchange rate between the functional and foreign currency. “At the date a foreign currency transaction is recognized, each asset, liability, revenue, expense, gain, or loss arising from the transaction shall be measured initially in the functional currency of the recording entity by use of the exchange rate in effect at that date.” [ASC 830-20-30-01]. Such exchange rates between bitcoin and the U.S. dollar are known and published.

Foreign currency transactions, while denominated in a foreign currency, are measured in the functional currency of the company. For example, a U.S. company purchasing €100,000 inventory from a London distributor would entry the follow journal entry, assuming a direct exchange rate of 1.30.

To record the purchase:

| | |
|------------------|-----------|
| Inventory | \$130,000 |
| Accounts Payable | \$130,000 |

If the payable were immediately paid, the U.S. company would simply purchase €100,000 with \$130,000.

To record the purchase of the Euro needed to pay the debt:

| | |
|--------------------|-----------|
| Investment in Euro | \$130,000 |
| Cash | \$130,000 |

Then the U.S. company would pay the foreign payable.

To record the payment of the debt:

| | |
|--------------------|-----------|
| Accounts Payable | \$130,000 |
| Investment in Euro | \$130,000 |

Gains and losses from transactions denominated in foreign currency arise when the payable (or receivable) is not immediately paid (received). In the above example, the amount actually paid to purchase €100,000 will change. For example, if the direct exchange rate changed to 1.35 at the date that the U.S. company purchased Euro and paid the debt, the company would be required to pay \$135,000 to pay the debt—\$5,000 more than originally needed. Foreign currency accounting requires that this \$5,000 difference be recognized as a loss, not as an increase in the value of the original asset purchased. The U.S. company would entry the following transactions (in addition to the original purchase).

To recognize the loss and increased debt:

| | |
|-----------------------|---------|
| Foreign Currency Loss | \$5,000 |
| Accounts Payable | \$5,000 |

To record the purchase of the Euro needed to pay the debt:

| | |
|--------------------|-----------|
| Investment in Euro | \$135,000 |
| Cash | \$135,000 |

To record the payment of the debt:

| | |
|--------------------|-----------|
| Accounts Payable | \$135,000 |
| Investment in Euro | \$135,000 |

A company buying inventory denominated in a virtual currency would be required to process the inventory purchase, subsequent revaluation of the debt, purchase of virtual currency, and payment of debt in virtual currency in this same manner.

The difference between the two methods of accounting for virtual currency-based transactions depends fundamentally on whether the virtual currency in question has an accepted value of its own that can be readily determined (typically as compared with other government-issued currencies). In other words, if the virtual currency does not have a known value, the other assets associated with the transaction will have to be used to determine the value of the virtual currency used. This is the basis of non-monetary exchanges. If the virtual currency does have a known, comparable value, the currency can be used to value the business transaction. This is the basis of foreign-currency exchange accounting.

Summary

From Satoshi Nakamoto's white paper introducing the technological concept behind Bitcoin, the stated purpose of this popular virtual currency is to provide a method of payment that is:

- not reliant on the financial industry, and
- provides anonymity to transaction participants.

Perhaps because of the current economic climate and related potentially harmful government monetary policies or perhaps because of the unique nature of Bitcoin's method combining both the mining Bitcoin and verification of Bitcoin transactions, this virtual currency has become more widely accepted than its predecessors.

If acceptance of virtual currency, such as Bitcoin, is to become more commonplace, standardized accounting rules need to be addressed. Two existing accounting methodologies that potentially can be used to record transactions measured in virtual currency are Non-monetary Exchanges and Foreign Currency Transactions. These two techniques are explained and reviewed within this paper.

Citations

Bitcoin.it wiki. How to accept Bitcoin, for small businesses. Bitcoin.it. Retrieved February 27, 2014. https://en.bitcoin.it/wiki/How_to_accept_Bitcoin_for_small_businesses.

Financial Accounting Standards Board. Accounting Standards Codification. "Accounting Standards Updates." Retrieved March 13, 2014 from <http://www.fasb.org/cs/ContentServer?site=FASB&c=Page&pagename=FASB%2FPage%2FSectionPage&cid=1176156316498>.

Financial Accounting Standards Board. "Issues Grouped by Type". Retrieved March 13, 2014 from http://www.fasb.org/cs/ContentServer?c=Document_C&pagename=FASB%2FDocument_C%2FDocumentPage&cid=1176163807130.

Kleinman, Alexis. 29 March, 2013. What Is Bitcoin, The Newest \$1 Billion Currency? *Huffington Post*. Retrieved March 13, 2014, from http://www.huffingtonpost.com/2013/03/29/what-is-bitcoin_n_2978872.html.

Love, Dylan. 12 March 2014. A New Browser Extension Turns Amazon Into A Bitcoin-Friendly Superstore. *Yahoo Finance*. Retrieved March 13, 2014, from <http://finance.yahoo.com/news/browser-extension-turns-amazon-bitcoin-175832311.html>.

Mt. Gox. February 27, 2014. Retrieved March 13, 2014, from https://www.mtgox.com_

Nakamoto, Satoshi. 2002. Bitcoin: Peer-to-Peer Electronic Cash System. Retrieved March 13, 2014 from <https://bitcoin.org/bitcoin.pdf>.

Samuelson, Robert J. "Boom or bust? Bitcoin craze is baffling". *Deseret News*. 21 January, 2014.

Sidel, Robin. "Bitcoin Group, Regulators to Meet." *Wall Street Journal*. 25 August 2013.

An Exploratory Investigation of Gender and Cross-Major Differences in Business Student Success in an IT Course

Taowen Le,¹ Jin Zhang,² and Wayne Wei Huang³

¹Weber State University, ²University of Wisconsin Milwaukee, ³Ohio University

Abstract

As information technology (IT) knowledge and skills become more and more essential to the success of modern business world, business students' future success is inevitably impacted by their ability to learn and master relevant IT. This study investigated whether male and female students would have the same potential for success in an IT-intensive business world, whether students of various business majors might enjoy the same level of success in an IT-sustained business environment, and whether special measures are necessary to ensure a proper preparation for all business students. Employing a variety of quantitative research methods (T-tests, ANOVA tests, post-hoc tests, and mean plots) and administering one comprehensive MS Access project, one comprehensive MS Excel project, eight timed quizzes, and three timed exams, this study monitored and analyzed academic performances of over 190 business students in an IT course offered at a major public university in the U.S. across two academic years. The

study specifically investigated potential gender differences and potential cross-major differences in business student success in an IT course. While male students seemed to have achieved slightly higher performance scores on the MS Access project and exams, female students seemed to have achieved slightly higher scores on the MS Excel project, quizzes, and overall performance. Except a small difference on exams, however, none of the other differences was statistically significant. While average performance scores seemed to differ across seven different major groups (Accounting, Business Management, Finance, Human Resource Management, Marketing, Supply Chain Management, Other[non-business]) on MS Access project, MS Excel project, quizzes, exams, and overall performance, almost all such differences were statistically insignificant with two exceptions: (1) On the MS Access project, students with Accounting, Business Administration, Finance, and Supply Chain Management majors performed better than students of Other (non-business) majors; and students with a Supply Chain Management major performed better than students with a Marketing major; and (2) On quizzes, Accounting students performed better than students of Finance, Marketing, and Supply Chain Management; and students of Business Administration and Other (non-business) majors performed better than students of Supply Chain Management major.

1. Introduction

Ever since the emergence of information technology (IT) as a keyword in the 1960s (Kline 2006), IT education has attracted the interests of researchers throughout the world. While the general learning process has been updated continuously, at least since the time of Socrates when the Socratic Method was popular (Kakabadse and Steane, 2010), IT educators understandably seem more interested in IT itself (Compeau and Higgins 1995; Bhattacharya et al. 2011; Karanikolas and Vassilakopoulos 2014; Tomasi 2014), IT applications in various disciplines (Shih 2011, Holmes et al. 2014; Strang 2015), assessment of IT programs (Goda and Reynolds 2010), or IT-supported learning environment (Surendra et al. 2009, Demirbilek 2010; Ng and Lai 2012; Ifenthaler and Schweinbenz 2013; Liu and Lee 2013; Ngafeeson and Sun 2015).

The frequent breakthroughs in the field of IT generate substantial challenges for IT instructors (Ruzic-Dimitrijevic et al. 2010). As new technologies emerge, many academic researchers have studied different teaching styles and methodology as applied to IT education with an

emphasis on instructor or curriculum development (Crawford 2000; Cohen 2002; Dadashzadeh et al. 2002; Luger 2006; Wagner et al. 2008; Bunch 2009; Abrahams and Singh 2010; Newby and Nguyen 2010; Olszak and Ziemba 2010). A few studies have also explored motivation of IT students or impact of student attitudes on learning outcomes of IT students (Palmer 2005; Nilsen 2007; Ballou and Huguenard 2008; Shroff et al. 2008; Le et al. 2011).

According to the Women in Technology Education Foundation, far fewer women are employed in the IT industry than men (WITEF 2015). In business colleges throughout the United States, there are far more female students majoring in traditional business disciplines such as Accounting, Human Resource (HR) Management, and Business Administration than in IT disciplines. It seems as though female students were avoiding IT disciplines.

As the business world continues to increase its dependency on IT and IT knowledge and skills become even more essential to the success of modern business fields, regardless of what disciplines students major in, their future success will be inevitably impacted by their ability to learn and master relevant IT. One would wonder whether male students and female students would have the same potential for success in an IT-intensive business world and whether students of various business majors might enjoy the same level of success in an IT-enabled business environment. If not, what measures might need to be implemented to ensure a proper preparation for all students.

As a general subject, gender difference in learning has been studied by researchers worldwide for many decades. A report from the National Institutes of Health found gender differences in favor of female students across all cultures studied, including Asian (China, Malaysia, India, the Philippines, Indonesia), North American (the United States), South American (Peru), African (sub-Saharan Africa), and European (Croatia, the Netherlands, Belgium, France, Germany, Italy, Norway, Portugal, Spain, Yugoslavia, and Russia) regions (Costa et al. 2001). Numerous other studies concluded that girls tend to exercise higher standards in the classroom, evaluate performances more critically, and outperform boys academically (Feingold 1994; Dwyer and Johnson 1997; Pomerantz et al. 2002). A more recent study of post-graduate students found no statistically significant difference between male and female students in education classes (Balam 2015).

But what about the IT discipline?

A search on major search engines as identified by an earlier study (Zhang et al. 2013) has revealed that no prior study seems to have explored the gender differences or cross-major differences in business student successes in IT Courses.

Information Technology for Beginners (IST3110) was an IT course offered within the business college of Weber State University to all non-IT business majors within the college. In addition to providing students with a systematic understanding of the basic technology of the IT field, the course was also targeted at generating awareness among students of the major IT advancements and developments as well as providing students hands-on experience with IT tools useful for academic and professional activities.

The researchers of this study monitored student performances in IST3110 for four consecutive semesters during the school years of 2012 to 2014. The major research questions for the study are whether there are any gender differences in business students and whether there are any cross-major differences among various business majors in terms of academic performance in an IT course.

With the findings of this study, the researchers hoped to provide insights to business colleges as to whether special measures should be implemented to ensure a proper preparation for all business students.

2. Research Design and Methodologies

This study utilized the course of Information Technology for Business (IST3110), an upper-level IT course offered to juniors and seniors in the business college at Weber State University in the United States. To address the proposed research questions, the study employed a quantitative research method (T-tests, ANOVA tests, post-hoc tests, and means plots).

2.1 The Course Design

The course was designed to be a 15-week, 3-credit-hour comprehensive IT course. It was designed to provide students with basic knowledge about the IT field, prepare them to use IT effectively to improve productivity and promote competitiveness in the marketplace, and provide them hands-on experience with the widely used Microsoft (MS) Excel and MS Access programs.

The course included 14 units of IT content ranging from hardware to software, from conceptual understanding to skill application, from IT infrastructure to information security, and from systems development to database management. Table 1 summarizes the course content.

2.2 The Administration of the Course

The course was administered in four consecutive semesters to business students at Weber State University during the academic years

| Table 1. Course content | | | | |
|--------------------------------|--|-------------------|-------------|----------------|
| Unit | Content | Covered by | | |
| | | Quiz | Exam | Project |
| 1 | Overview of IT and How IT Changes Business | | 1 | |
| 2 | Computer Hardware and Software | 1 | 1 | |
| 3 | Major Business Initiatives: Gaining Competitive Advantage with IT | 2 | 1 | |
| 4 | The World Wide Web and the Internet | 3 | 1 | |
| 5 | Computer Crime and Digital Forensics | | 1 | |
| 6 | Databases and Data Warehouses | 4 | 2 | |
| 7 | Database Implementation with Microsoft Access 2010 | 5 | 2 | 1 |
| 8 | Analytics, Decision Support, and Artificial Intelligence | 6 | 2 | |
| 9 | Electronic Commerce: Strategies for the New Economy | | 2 | |
| 10 | Decision Analysis with Microsoft Excel 2010 | | 3 | 2 |
| 11 | Systems Development: Phases, Tools, and Techniques | 7 | 3 | |
| 12 | Infrastructure, Cloud Computing, Metrics, and Business Continuity Planning | 8 | 3 | |
| 13 | Information Security: Threats and Safeguards | | 3 | |
| 14 | Emerging Trends and Technologies | | 3 | |

of 2012–2014: Autumn 2012, Spring 2013, Autumn 2013, and Spring 2014. Table 2 summarizes the students by gender for this study, and Table 3 summarizes the students by major for this study.

| Table 2. Gender of Students Enrolled in Study | | | |
|--|-----------------------------|-------------------------------|---------------------------------------|
| Semester | No. of Male Students | No. of Female Students | Total No. of Students Enrolled |
| Autumn 2012 | 27 | 18 | 45 |
| Spring 2013 | 34 | 15 | 49 |
| Autumn 2013 | 29 | 19 | 48 |
| Spring 2013 | 35 | 19 | 54 |
| Total | 125 | 71 | 196 |

| Table 3. Majors of Students Enrolled in Study | | | | | |
|--|--------------------|--------------------|--------------------|--------------------|------------------------------|
| Major | Autumn 2012 | Spring 2013 | Autumn 2013 | Spring 2014 | Total No. of Students |
| Accounting (A) | 17 | 14 | 21 | 16 | 68 |
| Business Administration (BA)* | 10 | 25 | 8 | 14 | 57 |
| Finance (F) | 7 | 2 | 5 | 5 | 19 |
| HR Management (HRM) | 1 | 2 | 4 | 2 | 9 |
| Marketing (M) | 6 | 1 | 4 | 7 | 18 |
| Supply Chain Management (SCM) | 3 | 3 | 3 | 8 | 17 |
| Others (Non-Business) (O)** | 1 | 2 | 3 | 2 | 8 |
| Total | 45 | 49 | 48 | 54 | 196 |

* General Business Administration (Including Business Management)

** Others (Non-Business Majors Including Integrated Studies, Health Information Management, Construction Management, Math, Communication, Spanish)

2.3 The Execution of Study and Collection of Data

The same textbook, course content, teaching methodologies, instructions, measurement instruments, and grading procedures were administered to all students during the four semesters of the study period.

In each semester, students were required to complete two 35-point comprehensive hands-on projects. In the first project, students were given a set of specifications and were asked to create an MS Access database following the specifications; they were also required to populate the database with provided data, design and execute queries of varying complexity levels to address provided inquiries, and design a fairly complex professional report and a professional data entry form. In the second project, students were provided a set of MS Excel worksheets populated with industry data and were asked to perform various data analysis tasks including different levels of AutoFilter, Custom Filter, Conditional Formatting, and pivot-tables.

In addition, students were also required to take eight timed 10-point quizzes. Each quiz focused on one particular unit and consisted of custom-designed multiple-choice questions.

Each semester, students were also required to take three timed 100-point exams. Each exam consisted of 40 multiple choice questions and covered four to five units of the course textbook. Table 1 summarizes the coverage of projects, quizzes, and exams.

Thus, the total maximum score each student could receive on the two project assignments, eight quizzes, and the three exams would be 450 ($35 \times 2 + 10 \times 8 + 100 \times 3$).

At the end of the four semesters, average project scores (0–35), quiz scores (0–10), examination scores (0–100), and final total scores (0–450) for each gender and for each of the seven major groups were also collected and tabulated.

Scores of male students and scores of female students were compared and analyzed to assess any gender differences in student academic performance. Scores of the various majors were also compared and analyzed to assess cross-major differences in student academic performance.

2.4 Hypotheses

Because the performance of a student in the course is well reflected in project assignments, quizzes, examinations, and overall achievements, 10 individual hypotheses based on project assignments, quizzes, examinations, and overall achievements, respectively, were proposed to answer the overarching research questions in the study.

H1_1: There is no significant difference between male and female students in academic performance on MS Access project assignment.

H1_2: There is no significant difference between male and female students in academic performance on MS Excel project assignment.

H1_3: There is no significant difference between male and female students in academic performance on quizzes.

H1_4: There is no significant difference between male and female students in academic performance on examinations.

H1_5: There is no significant difference between male and female students in overall academic performance.

H1_6: There is no significant difference among different majors in academic performance on MS Access project assignment.

H1_7: There is no significant difference among different majors in academic performance on MS Excel project assignment.

H1_8: There is no significant difference among different majors in academic performance on quizzes.

H1_9: There is no significant difference among different majors in academic performance on examinations.

H1_10: There is no significant difference among different majors in overall academic performance.

The overall academic performance of a student was measured by his/her MS Access project assignment score, MS Excel project assignment score, average quiz score, average examination score, and final total score in the course.

A T-test method was used to test hypotheses H1_1 to H1_5 because these hypotheses have two variables, and ANOVA tests and post-hoc tests were used to analyze hypotheses H1_6 to H1_10 because these hypotheses involve multiple variables. Mean comparison or mean plots was used for descriptive analyses.

The significance level (p) is 0.05 for all the tests in this study. In other words, if p is smaller than 0.05 in a test, the finding of the test is statistically significant and the corresponding null hypothesis is rejected; otherwise, the null hypothesis is accepted.

2.5 Research Limitation

Since IST3110 was a normal academic course at Weber State University, not a specially designed research class, the number of male students and the number of female students were not equal, and the number of students across different majors were not evenly distributed, either. The more ideal setting would be a specially designed research class with equal number of students across genders and across majors.

3. Findings and Analyses

3.1 Gender Difference Analysis—MS Access Project

H1_1: There is no significant difference between male and female students in academic performance on MS Access project assignment.

The mean score of male students (33.5242) was slightly larger than the mean score of female students (33.4014) (Table 4). When equal variances were assumed, the p is 0.368, which is larger than 0.05, so the proposed hypothesis is accepted. It indicates that there was no significant difference between male students and female students. It suggests that although male students seem to have achieved slightly high scores than female students on MS Access project, such difference is statistically insignificant.

| Table 4. Group Statistics for MS Access Project Scores | | | | | |
|---|---------------|----------|-------------|-----------|------------|
| | Gender | N | Mean | SD | SEM |
| MS Access Project | Male | 124 | 33.5242 | 2.73256 | .24539 |
| | Female | 71 | 33.4014 | 2.86558 | .34008 |

3.2 Gender Difference Analysis—MS Excel Project

H1_2: There is no significant difference between male and female students in academic performance on MS Excel project assignment.

The mean score of male students (33.2339) was slightly smaller than the mean score of female students (33.5634) (Table 5). The p is 0.540, indicating the proposed hypothesis is accepted ($p > 0.05$). There was no significant difference between male and female students, which suggests that although female students seem to have achieved high scores than male students on the MS Excel project, such difference was statistically insignificant.

| Table 5. Group Statistics for MS Excel Project Scores | | | | | |
|--|---------------|----------|-------------|-----------|------------|
| | Gender | N | Mean | SD | SEM |
| MS Excel Project | Male | 124 | 33.2339 | 2.03069 | .18236 |
| | Female | 71 | 33.5634 | 2.30671 | .27376 |

3.3 Gender Difference Analysis—Quizzes

H1_3: There is no significant difference between male and female students in academic performance on quizzes.

As shown in Table 6, the mean score of male students (8.2026) was slightly smaller than the mean score of female students (8.3451). With a p of 0.642, the proposed hypothesis is accepted ($p > 0.05$). It indicates that there is no significant difference between male students and female students. It suggests that although female students seem to have achieved higher scores than male students on quizzes, such difference is statistically insignificant.

| Table 6. Group Statistics for Quiz Scores | | | | | |
|--|---------------|----------|-------------|-----------|------------|
| | Gender | N | Mean | SD | SEM |
| Average Quiz Score | Male | 125 | 8.2026 | .80750 | .07222 |
| | Female | 71 | 8.3451 | .88347 | .10485 |

3.4 Gender Difference Analysis -- Exams

H1_4: There is no significant difference between male and female students in academic performance on examinations.

Table 7 shows the mean score on exams: the mean score of male students (79.6626) was higher than the mean score of female students (79.3485). The p is 0.039, which is smaller than 0.05, indicates the proposed hypothesis is rejected. There was a significant difference between male and female students, suggesting that the male students achieved better performance on exams than the female students.

| Table 7. Group Statistics for Exam Scores | | | | | |
|--|---------------|----------|-------------|-----------|------------|
| | Gender | N | Mean | SD | SEM |
| Average Exam Score | Male | 125 | 79.6626 | 7.13168 | .63788 |
| | Female | 71 | 79.3485 | 8.66726 | 1.02861 |

3.5 Gender Difference Analysis—Overall Performance

H1_5: There is no significant difference between male and female students in overall academic performance.

As shown in Table 8, the mean score of male students (364.1208) is smaller than the mean score of female students (366.5775). With a p of 0.160, which is larger than 0.05, the proposed hypothesis is accepted. It indicates that there is no significant difference between male and female students. This suggests that although female students seem to have achieved better overall performance than male students, such difference is statistically insignificant.

| Table 8. Group Statistics for Total Scores | | | | | |
|---|---------------|----------|-------------|-----------|------------|
| | Gender | N | Mean | SD | SEM |
| Overall Mean Score | Male | 125 | 364.1208 | 35.56350 | 3.18090 |
| | Female | 71 | 366.5775 | 38.10143 | 4.52181 |

3.6 Cross-Major Analysis—MS Access Project

H1_6: There is no significant difference among different majors in academic performance on MS Access project assignment.

In Table 9, Supply Chain Management majors had the largest average score (34.2941), followed by Finance majors (33.8684), Accounting majors (33.7687), Business Administration majors (33.6491), Marketing majors (32.4167), Human Resource majors (32.3333), and Other (non-business) majors (30.8750). Figure 1 pictorially shows the differences among these majors. The statistical

| Table 9. One-way Descriptives for MS Access Project | | | | | | | | |
|---|-----|---------|---------|---------|----------------|-------------|-------|-------|
| Maj. | N | Mean | SD | SEM | 95% CI of mean | | Min | Max |
| | | | | | Lower Bound | Upper Bound | | |
| A | 67 | 33.7687 | 2.21279 | .27033 | 33.2289 | 34.3084 | 20.50 | 35.00 |
| BA | 57 | 33.6491 | 1.87789 | .24873 | 33.1509 | 34.1474 | 28.00 | 35.00 |
| F | 19 | 33.8684 | 1.66535 | .38206 | 33.0657 | 34.6711 | 28.50 | 35.00 |
| HRM | 9 | 32.3333 | 2.61008 | .87003 | 30.3271 | 34.3396 | 28.00 | 35.00 |
| M | 18 | 32.4167 | 5.20534 | 1.22691 | 29.8281 | 35.0052 | 12.50 | 35.00 |
| SCM | 17 | 34.2941 | .98518 | .23894 | 33.7876 | 34.8007 | 31.00 | 35.00 |
| O | 8 | 30.8750 | 6.37938 | 2.25545 | 25.5417 | 36.2083 | 15.50 | 35.00 |
| Total | 195 | 33.4795 | 2.77500 | .19872 | 33.0876 | 33.8714 | 12.50 | 35.00 |

Majors: A, Accounting; BA, Business Administration; F, Finance; HRM, Human Resources Management; M, Marketing; SCM, Supply Chain Management; O, Other

analysis, shown in Table 10, shows the resultant F value is 2.437, df is 6, and the p is 0.027, which is smaller than 0.05. The proposed hypothesis is therefore rejected at the significance level of 0.05. This indicates that there are significant differences among different majors.

Post-hoc tests (Appendix Table 1) revealed that the statistically significant differences lie between (1) Accounting majors and Other (non-business) majors ($p=0.005$), (2) Business Administration majors and Other (non-business) majors ($p=0.007$), (3) Finance majors and

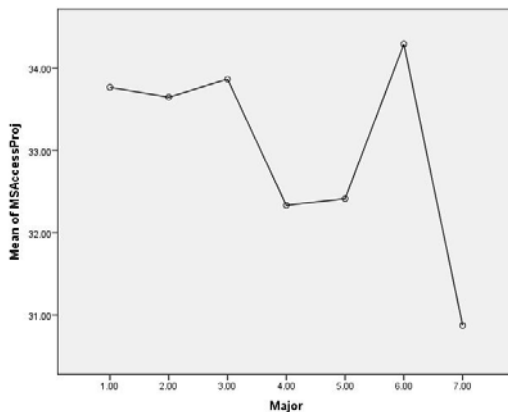


Figure 1. Mean plot for MS Access project

| Table 10. One-way ANOVA for MS Access Project | | | | | |
|--|-----------------------|-----------|---------------------|----------|----------|
| | Sum of Squares | df | Mean Squares | F | p |
| Between Groups | 107.821 | 6 | 17.970 | 2.437 | .027 |
| Within Groups | 1386.097 | 188 | 7.373 | | |
| Total | 1493.918 | 194 | | | |

Other (non-business) majors ($p=0.010$), (4) Supply Chain Management majors and Other (non-business) majors ($p=0.004$), and (5) Marketing majors and Supply Chain Management majors ($p=0.042$). The test results suggest that students of Accounting, Business Administration, Finance, and Supply Chain Management performed better than students of Other (non-business) majors and that students with a Supply Chain major performed better than students with Marketing major.

3.7 Cross-Major Analysis – MS Excel Project

H1_7: There is no significant difference among different majors in academic performance on MS Excel project assignment.

As shown in Table 11, Supply Chain Management majors had the highest average score (33.6176), followed by Human Resource Management majors (33.6111), Marketing majors (33.5278), Business Administration majors (33.3947), Accounting majors (33.3358), Finance majors (33.0263), and Other (non-business) majors (32.7500). Figure 2 pictorially shows the differences among these majors. The statistical analysis shown in Table 12 shows the resultant F value is

| Table 11. One-way Descriptives for MS Excel Project | | | | | | | | |
|--|----------|-------------|-----------|------------|-----------------------|--------------------|------------|------------|
| Maj. | N | Mean | SD | SEM | 95% CI of mean | | Min | Max |
| | | | | | Lower Bound | Upper Bound | | |
| A | 67 | 33.3358 | 2.37472 | .29012 | 32.7566 | 33.9151 | 20.00 | 35.00 |
| BA | 57 | 33.3947 | 2.12077 | .28090 | 32.8320 | 33.9575 | 25.50 | 35.00 |
| F | 19 | 33.0263 | 1.79872 | .41265 | 32.1594 | 33.8933 | 29.50 | 35.00 |
| HRM | 9 | 33.6111 | 1.51612 | .50537 | 32.4457 | 34.7765 | 31.00 | 35.00 |
| M | 18 | 33.5278 | 1.38768 | .32708 | 32.8377 | 34.2179 | 30.00 | 35.00 |
| SCM | 17 | 33.6176 | 2.43368 | .59025 | 32.3664 | 34.8689 | 27.00 | 35.00 |
| O | 8 | 32.7500 | 2.64575 | .93541 | 30.5381 | 34.9619 | 27.00 | 35.00 |
| Total | 195 | 33.3538 | 2.13535 | .15292 | 33.0523 | 33.6554 | 20.00 | 35.00 |

Majors: A, Accounting; BA, Business Admn; F, Finance, HRM, Human Resources Mgmt; M, Marketing; SCM, Supply Chain Mgmt; O, Other

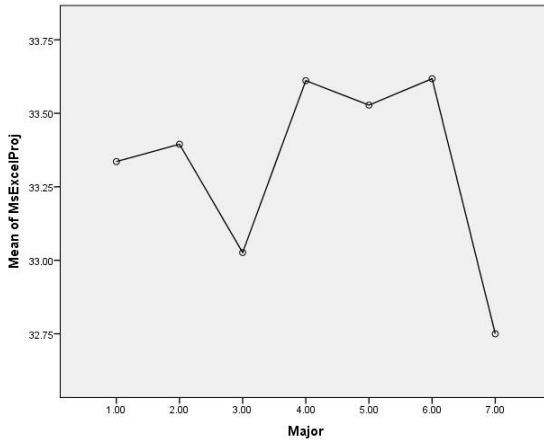


Figure 2. Mean plot for MS Excel project

0.264, df is 6, and p is 0.953, which is larger than 0.05. The proposed hypothesis is therefore accepted at the significance level of 0.05. It indicates that there is no significant difference among different majors.

| Table 12. One-way ANOVA for MS Excel Project | | | | | |
|---|----------------|-----|-------------|------|------|
| | Sum of Squares | df | Mean Square | F | p |
| Between Groups | 7.396 | 6 | 1.233 | .264 | .953 |
| Within Groups | 877.189 | 188 | 4.666 | | |
| Total | 884.585 | 194 | | | |

3.8 Cross-Major Analysis—Quizzes

H1_8: There is no significant difference among different majors in academic performance on quizzes.

Other (non-business) majors had the largest average score (8.5525), followed by Accounting majors (8.4759), Business Administration majors (8.3084), Marketing majors (8.0106), Human Resource Management majors (8.0089), Finance majors (7.9905), and Supply Chain Management Majors (7.7276) (Table 13). Figure 3 pictorially shows the differences among these majors. The ANOVA indicates the resultant F value is 3.001, df is 6, the p is 0.008, which is smaller than 0.05 (Table 14). The proposed hypothesis is therefore

| Maj. | N | Mean | SD | SEM | 95% CI of mean | | Min | Max |
|-------|-----|--------|--------|--------|----------------|-------------|------|-------|
| | | | | | Lower Bound | Upper Bound | | |
| A | 68 | 8.4759 | .82489 | .10003 | 8.2762 | 8.6755 | 5.83 | 10.00 |
| BA | 57 | 8.3084 | .76970 | .10195 | 8.1042 | 8.5127 | 6.25 | 10.00 |
| F | 19 | 7.9905 | .70699 | .16220 | 7.6498 | 8.3313 | 6.79 | 9.38 |
| HRM | 9 | 8.0089 | .95233 | .31744 | 7.2769 | 8.7409 | 6.79 | 10.00 |
| M | 18 | 8.0106 | .84680 | .19959 | 7.5895 | 8.4317 | 6.67 | 9.64 |
| SCM | 17 | 7.7276 | .96917 | .23506 | 7.2293 | 8.2259 | 6.25 | 10.00 |
| O | 8 | 8.5525 | .57415 | .20299 | 8.0725 | 9.0325 | 7.50 | 9.38 |
| Total | 196 | 8.2542 | .83639 | .05974 | 8.1364 | 8.3720 | 5.83 | 10.00 |

Majors: A, Accounting; BA, Business Administration; F, Finance; HRM, Human Resources Management; M, Marketing; SCM, Supply Chain Management; O, Other

rejected at the significance level of 0.05. It indicates that there are significant differences among different majors. Post-hoc tests (Appendix Table 2) further reveal that the statistically significant differences lie between (1) Accounting majors and Finance majors ($p=.022$), (2) Accounting majors and Marketing majors ($p=.032$), (3) Accounting majors and Supply Chain Management majors ($p=.001$),

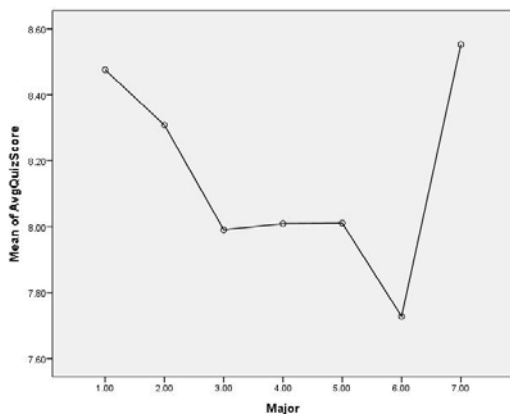


Figure 3. Mean plots for quizzes

(4) Business Administration majors and Supply Chain Management majors ($p=.010$), (5) Supply Chain Management majors and Other (non-business) majors ($p=.019$). The test results suggest that Accounting students performed better than students of Finance, Marketing, and Supply Chain Management majors and that students of Business Administration and Other (non-business) majors performed better than Supply Chain Management students.

| Table 14. One-way ANOVA for Quizzes | | | | | |
|--|-----------------------|-----------|--------------------|----------|----------|
| | Sum of Squares | df | Mean Square | F | p |
| Between Groups | 11.866 | 6 | 1.978 | 3.001 | .008 |
| Within Groups | 124.545 | 189 | .659 | | |
| Total | 136.411 | 195 | | | |

3.9 Cross-Major Analysis—Exams

H1_9: There is no significant difference among different majors in academic performance on examinations.

As shown in Table 15, Supply Chain Management majors had the highest average score on exams (81.8135), followed by Other (non-business) majors (80.3650), Accounting majors (80.0862), Human Resource Management majors (79.0733), Marketing majors (78.9350),

| Table 15. One-way Descriptives for Exams | | | | | | | | |
|---|----------|-------------|-----------|------------|-----------------------|--------------------|------------|------------|
| Maj. | N | Mean | SD | SEM | 95% CI of mean | | Min | Max |
| | | | | | Lower Bound | Upper Bound | | |
| A | 68 | 80.0862 | 8.70437 | 1.05556 | 77.9793 | 82.1931 | 58.33 | 96.67 |
| BA | 57 | 78.6819 | 7.91595 | 1.04849 | 76.5815 | 80.7823 | 54.17 | 94.17 |
| F | 19 | 78.6626 | 6.39346 | 1.46676 | 75.5811 | 81.7442 | 65.83 | 91.67 |
| HRM | 9 | 79.0733 | 6.15911 | 2.05304 | 74.3390 | 83.8076 | 68.33 | 88.33 |
| M | 18 | 78.9350 | 5.65902 | 1.33384 | 76.1208 | 81.7492 | 70.83 | 89.17 |
| SCM | 17 | 81.8135 | 6.18219 | 1.49940 | 78.6349 | 84.9921 | 70.00 | 90.00 |
| O | 8 | 80.3650 | 9.33803 | 3.30149 | 72.5582 | 88.1718 | 67.50 | 95.00 |
| Tot | 196 | 79.5488 | 7.70272 | .55019 | 78.4637 | 80.6339 | 54.17 | 96.67 |

Majors: A, Accounting; BA, Business Administration; F, Finance, HRM, Human Resources Management; M, Marketing; SCM, Supply Chain Management; O, Other

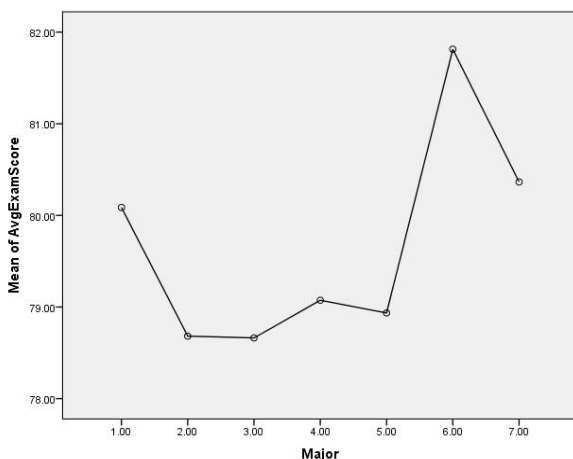


Figure 4. Mean plot for exams

Business Administration majors (78.6819), and Finance majors (78.6626). Figure 4 pictorially shows the differences among these majors. The resultant F value is 0.494, df is 6, the p is 0.812, which is larger than 0.05 (Table 16). The proposed hypothesis is therefore accepted at the significance level of 0.05. It indicates that there is no significant difference among different majors. Although Supply Chain Management majors scored approximately 3 points more than Business Administration majors and Finance majors, these differences are not statistically significant.

| | Sum of Squares | df | Mean Square | F | p |
|----------------|-----------------------|-----------|--------------------|----------|----------|
| Between Groups | 178.729 | 6 | 29.788 | .494 | .812 |
| Within Groups | 11390.989 | 189 | 60.270 | | |
| Total | 11569.718 | 195 | | | |

3.10 Cross-Major Analysis—Overall Performance

H1_10: There is no significant difference among different majors in overall academic performance.

Table 17 shows that Supply Chain Management majors had the highest average total score (372.1765), followed by Accounting majors (367.5515), Business Administration majors (364.9316), Human

Resource Management majors (364.0000), Finance majors (361.3684), Marketing majors (359.4167), and Other (non-business) majors (351.1250). Figure 5 pictorially shows the differences among these majors. In Table 18, the resultant F value is 0.454, df is 6, the p is 0.841, which is larger than 0.05. The proposed hypothesis is therefore accepted at the significance level of 0.05. This indicates that there is no significant difference among different majors. Although Supply Chain Management majors scored 21 points more than the Other (non-business) majors, this difference and all other differences are statistically insignificant.

| Maj. | N | Mean | SD | SEM | 95% CI of mean | | Min | Max |
|-------|-----|----------|---------|--------|----------------|-------------|--------|--------|
| | | | | | Lower Bound | Upper Bound | | |
| A | 68 | 367.5515 | 44.7046 | 5.4212 | 356.7307 | 378.3723 | 140.00 | 430.00 |
| BA | 57 | 364.9316 | 31.5415 | 4.1778 | 356.5625 | 373.3007 | 267.50 | 419.50 |
| F | 19 | 361.3684 | 30.0245 | 6.8881 | 346.8971 | 375.8397 | 281.50 | 409.00 |
| HRM | 9 | 364.0000 | 26.8200 | 8.9400 | 343.3843 | 384.6157 | 326.50 | 414.50 |
| M | 18 | 359.4167 | 24.5682 | 5.7908 | 347.1992 | 371.6341 | 320.00 | 400.50 |
| SCM | 17 | 372.1765 | 26.6862 | 6.4724 | 358.4557 | 385.8973 | 334.50 | 417.00 |
| O | 8 | 351.1250 | 55.8012 | 19.729 | 304.4741 | 397.7759 | 235.00 | 424.50 |
| Total | 196 | 365.0107 | 36.4251 | 2.6018 | 359.8794 | 370.1420 | 140.00 | 430.00 |

Majors: A, Accounting; BA, Business Administration; F, Finance; HRM, Human Resources Management; M, Marketing; SCM, Supply Chain Management; O, Other

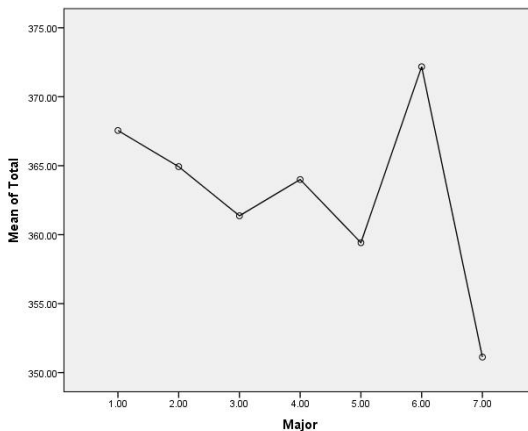


Figure 5. Mean plot for overall performance

| Table 18. One-way ANOVA for Overall Performance | | | | | |
|--|-----------------------|-----------|--------------------|----------|----------|
| | Sum of Squares | df | Mean Square | F | p |
| Between Groups | 3679.283 | 6 | 613.214 | .454 | .841 |
| Within Groups | 255044.905 | 189 | 1349.444 | | |
| Total | 258724.188 | 195 | | | |

4. Conclusion

As the business world continues to leverage IT, and as IT continues to transform business organizations, future success of business students today will depend to a great degree on their possession and mastery of IT knowledge and skills. It is important for college educators to be aware of any potential gender differences and cross-major differences that might exist in student success in IT courses so that proper measures might be implemented to provide solid IT preparation for all business students.

Through two school years and four consecutive semesters of exploratory investigation, utilizing a variety of quantitative research methods (T-tests, ANOVA tests, post-hoc tests, and mean plots), we investigated potential gender and cross-major differences in business student successes in a comprehensive IT course. Male students performed better on exams than female students, but there were no significant difference between male and female students on MS Access project, MS Excel project, or quizzes. Despite better performance on the exams by the male students, no gender difference existed on overall performance either. Male and female students demonstrated the same level of potential for success with IT.

While average performance scores seemed to differ across seven different major groups (Accounting, Business Management, Finance, Human Resource Management, Marketing, Supply Chain Management, Other [non-business]) on MS Access project, MS Excel project, quizzes, and exams, almost all such differences were statistically insignificant with two exceptions: (1) On the MS Access project, Accounting, Business Administration, Finance, and Supply Chain Management majors performed better than Other (non-business) majors and Supply Chain majors performed better than Marketing majors. (2) On quizzes, Accounting majors performed better than Finance, Marketing, and Supply Chain Management majors and Business Administration and Other (non-business) majors performed better than Supply Chain Management majors. Despite the scattered individual differences, no statistically significant difference in overall

performance existed among the various majors. Students of different majors demonstrated the same level of potential for success with IT.

With the findings of this study, professors teaching IT courses to business students can rest assured that no special measures need to be implemented to help one gender or the other, and no special measures need to be implemented to help any particular major. Although IT seems to be a field of male dominance, as long as proper IT curriculum is provided, business colleges can assure their students that all of them, regardless of their majors, male or female, will have the same potential for success in an IT-intensive business world. Information Systems departments or programs in business colleges could persuade more female students to major in information systems disciplines.

Future research projects may include, but are not limited to, a controlled study of gender differences among randomly selected college students taking IT courses, a controlled study of non-IT majors against IT majors in terms of academic success in IT courses, and a study of enabling and hindering factors that impact student decisions pertaining to IT discipline as an academic major.

References

Abrahams, A.S. and Singh T. "An Active, Reflective Learning Cycle for E-Commerce Classes: Learning about E-Commerce by Doing and Teaching," 2010. *Journal of Information Systems Education*, Vol. 21, No. 4, 383-390.

Balam, E.M. "Learning Strategies and Motivation of Graduate Students: Is Gender a Factor?" 2015. *Institute for Learning Styles Journal*, Vol. 1, Spring Issue, 1-9.

Ballou, D.J. and Huguenard, B.R. "The Impact of Students' Perceived Computer Experience on Behavior and Performance in an Introductory Information Systems Course," 2008. *Journal of Information Systems Education*, Vol. 19, No. 1, 87-98.

Bhattacharya, D., Ghosh, J., Boccardo, P., and Samadhiya N.K. "Wireless hazard communication system," 2011. *Journal of Systems and Information Technology*, Vol. 13, No. 4, 408-424.

Bunch, J.M. "A Constructivist Approach to Teaching Web Development in Post-Secondary Vocational Settings," 2009. *Journal of Information Technology Education*, Vol. 8, 257-271.

Cohen, E.B. *Challenges of Information Technology Education in the 21st Century*. Hershey, PA: IGI Publishing, 2002.

Compeau, D.R. and Higgins, C.A. "Computer Self-Efficacy: Development of a Measure and Initial Test," 1995. *MIS Quarterly*, Vol. 19, No. 2, 189-211.

Costa, P., Terracciano, A., and McCrae, R. "Gender differences in personality traits across cultures: robust and surprising findings," 2001. *Journal of Personality and Social Psychology*, Vol. 81, No. 2, 322-331.

Crawford, R. "Information Technology in Secondary Schools and Its Impact on Training Information Technology Teachers," 2000. *Journal of Information Technology for Teacher Education*, Vol. 9, No. 2, 183-197.

Dadashzadeh, M., Saber, A., and Saber, S. *Information Technology Education in the New Millennium*. Hershey, PA: IRM Press, 2002.

Demirbilek, M. "Investigating attitudes of adult educators towards educational mobile media and games in eight European countries," 2010. *Journal of Information Technology Education: Research*, Vol. 9, 2010, 235-247.

Dwyer, C. A. and Johnson L. M. "Grades, Accomplishments, and Correlates," in *Gender and Fair Assessment* by Willingham, W.W. and Cole, N.S (eds.), Mahwah, NJ: Lawrence Erlbaum Associates, 1997, 127-156.

Feingold, A. "Gender Differences in Personality: a Meta-Analysis," 1994. *Psychological Bulletin*, Vol. 116, 429-456.

Goda, B.S. and Reynolds, C. "Improving outcome assessment in information technology program accreditation," 2010. *Journal of Information Technology Education: Innovations in Practice*, Vol. 9, No. 1, 49-59.

Holmes, K., Greenhill, A., and McLean, R. "Creating communities: the use of technology in craft and DIY communities of practice," 2014. *Journal of Systems and Information Technology*, Vol. 16, No. 4, 277-295.

Ifenthaler, D. and Schweinbenz, V. "The Acceptance of Tablet-PCs in Classroom Instruction: The Teachers' Perspectives," 2013. *Computers in Human Behavior*, Vol. 29, No. 3, 525-534.

Kakabadse, N. and Steane, P. "Meaning and Interpretation: Insights and Discourse," 2010. *Journal of Management History*, Vol. 16, No. 3, 346-366.

Karanikolas, N. and Vassilakopoulos, M. "Comparison of Post-Relational and Object-Relational modelling for real-world database applications," 2014. *Journal of Systems and Information Technology*, Vol. 16, No. 4, 313-340.

Kline, R. "Cybernetics, Management Science, and Technology Policy: The Emergence of 'Information Technology' as a Keyword, 1948-1985," 2006. *Technology and Culture*, Vol. 47, No. 3, 513-535.

Le, T., Zhang, J. and Harris, E. "An exploratory investigation of the impact of surprise interviews with former graduates on online students learning in an introductory IT course," 2011. *International Journal of Internet and Enterprise Management*, Vol. 7, No. 4, 388-400.

Liu, Z.F. and Lee, C.Y. "Using peer feedback to improve learning via online peer assessment," 2013. *Turkish Online Journal of Educational Technology*, Vol. 12, No. 1, 187-199.

Luger, E. *A Literature Review of Exemplary Practice in the Training of IT Tutors*, 2006. UK: National Institute of Adult and Continuing Education.

Newby, M. and Nguyen T.H. "Using the Same Problem with Different Techniques in Programming Assignments: an Empirical Study of Its Effectiveness," 2010. *Journal of Information Systems Education*, Vol. 21, No. 4, 375-382.

Nilsen, H. "Motivation and Learning Strategies of IS Students: From Theory to Practice," 2007. *Proceedings of the 2007 Computer Science and IT Education Conference*, 521-535.

Ng, E. and Lai, Y. "An Exploratory Study on Using Wiki to Foster Student Teachers Learner-centered Learning and Self and Peer Assessment," 2012. *Journal of Information Technology Education: Innovations in Practice*, Vol. 11, No. 1, 71-84.

Ngafeeson, M.N. and Sun, J. "The Effects of Technology Innovativeness and System Exposure on Student Acceptance of E-Textbooks," 2015. *Journal of Information Technology Education: Research*, Vol. 14, 2015, 55-71.

Olszak, C. and Ziemba, E. "Knowledge Management Curriculum Development: Linking with Real Business Needs," 2010. *Issues in Information Science and Information Technology*, Vol. 7, 235-248.

Palmer, D. "A Motivational View of Constructivist-Informed Teaching," 2005. *International Journal of Science Education*, Vol. 27, No. 15, 1853-1881.

Pomerantz, E., Altermatt, E., and Saxon, J. "Making the Grade but Feeling Distressed: Gender Differences in Academic Performance and Internal Distress," 2002. *Journal of Educational Psychology*, Vol. 94, No. 2, 396-404.

Ruzic-Dimitrijevic, L. and Dimitrijevic, M. "Challenges IT Instructors Face in the Self-Education Process," 2010. *Journal of Information Technology Education: Innovations in Practice*, Vol. 9, No. 1, 35-48.

Shih, R.C. "Can Web 2.0 Technology Assist College Students in Learning English Writing? Integrating Facebook and Peer Assessment with Blended Learning," 2011. *Australasian Journal of Educational Technology*, Vol. 27, No. 5, 829-845.

Shroff, R.H., Vogel, D.R., and Coombes, J. "Assessing Individual-level Factors Supporting Student Intrinsic Motivation in Online Discussions: A Qualitative Study," 2008. *Journal of Information Systems Education*, Vol. 19, No. 1, 111-126.

Strang, K. D. "Effectiveness of Peer Assessment in a Professionalism Course Using an Online Workshop," 2015. *Journal of Information Technology Education: Innovations in Practice*, Vol. 14, 2015, 1-16.

Surendra, N.C. and Denton, J.W. "Designing IS Curricula for Practical Relevance: Applying Baseball's 'Moneyball' Theory," 2009. *Journal of Information Systems Education*, Vol. 20, No. 1, 77-86.

Tomasi, S.D. "Using Cues to Forage for Information on the Web," 2014. *Journal of Systems and Information Technology*, Vol. 16. No. 4, 296-312.

Wagner, T.A., Longenecker, H.E., and Saunier, B.M. "A Methodology to Assist Faculty in Developing Successful Approaches for Achieving Learner Centered Information Systems Curriculum Outcomes: Team Based Methods," 2008. Journal of Information Systems Education, Vol. 19, No. 2, 181-196.

WITEF. "Women in Technology Education Foundation Resources," 2015. Accessed March 2, 2015, from <http://www.womenintechology.org/witef/resources>.

Zhang, J., Fei, W., Le, T. "A Comparative Analysis of the Search Feature Effectiveness of the Major English and Chinese Search Engines," 2013. Online Information Review, Vol. 37, No. 2, 217-230

Appendices

| Appendix Table 1. Post-Hoc Tests for MS Access Project | | | | | | |
|---|----------------------|--------------------------------------|-----------------------|-------------|------------------------|------------------------|
| I (Major) | J (Major) | Mean Difference (I-J) | Std. Error | Sig. | 95% CI | |
| | | | | | Lower Bound | Upper Bound |
| A | BA | .11953 | .48928 | .807 | -.8456 | 1.0847 |
| | F | -.09976 | .70575 | .888 | -1.4920 | 1.2924 |
| | HRM | 1.43532 | .96398 | .138 | -.4663 | 3.3369 |
| | M | 1.35199 | .72086 | .062 | -.0700 | 2.7740 |
| | SCM | -.52546 | .73739 | .477 | -1.9801 | .9292 |
| | O | 2.89366* | 1.01570 | .005 | .8900 | 4.8973 |
| BA | A | -.11953 | .48928 | .807 | -1.0847 | .8456 |
| | F | -.21930 | .71930 | .761 | -1.6382 | 1.1996 |
| | HRM | 1.31579 | .97394 | .178 | -.6055 | 3.2370 |
| | M | 1.23246 | .73413 | .095 | -.2157 | 2.6807 |
| | SCM | -.64499 | .75036 | .391 | -2.1252 | .8352 |
| | O | 2.77412* | 1.02516 | .007 | .7518 | 4.7964 |
| F | A | .09976 | .70575 | .888 | -1.2924 | 1.4920 |
| | BA | .21930 | .71930 | .761 | -1.1996 | 1.6382 |
| | HRM | 1.53509 | 1.09875 | .164 | -.6324 | 3.7026 |
| | M | 1.45175 | .89311 | .106 | -.3101 | 3.2136 |
| | SCM | -.42570 | .90650 | .639 | -2.2139 | 1.3625 |
| | O | 2.99342* | 1.14440 | .010 | .7359 | 5.2509 |

| | | | | | | |
|-----|-----|-----------|---------|------|---------|---------|
| HRM | A | -1.43532 | .96398 | .138 | -3.3369 | .4663 |
| | BA | -1.31579 | .97394 | .178 | -3.2370 | .6055 |
| | F | -1.53509 | 1.09875 | .164 | -3.7026 | .6324 |
| | M | -.08333 | 1.10852 | .940 | -2.2701 | 2.1034 |
| | SCM | -1.96078 | 1.11933 | .081 | -4.1688 | .2473 |
| | O | 1.45833 | 1.31940 | .270 | -1.1444 | 4.0611 |
| M | A | -1.35199 | .72086 | .062 | -2.7740 | .0700 |
| | BA | -1.23246 | .73413 | .095 | -2.6807 | .2157 |
| | F | -1.45175 | .89311 | .106 | -3.2136 | .3101 |
| | HRM | .08333 | 1.10852 | .940 | -2.1034 | 2.2701 |
| | SCM | -1.87745* | .91831 | .042 | -3.6890 | -.0659 |
| | O | 1.54167 | 1.15378 | .183 | -.7344 | 3.8177 |
| SCM | A | .52546 | .73739 | .477 | -.9292 | 1.9801 |
| | BA | .64499 | .75036 | .391 | -.8352 | 2.1252 |
| | F | .42570 | .90650 | .639 | -1.3625 | 2.2139 |
| | HRM | 1.96078 | 1.11933 | .081 | -.2473 | 4.1688 |
| | M | 1.87745* | .91831 | .042 | .0659 | 3.6890 |
| | O | 3.41912* | 1.16418 | .004 | 1.1226 | 5.7156 |
| O | A | -2.89366* | 1.01570 | .005 | -4.8973 | -.8900 |
| | BA | -2.77412* | 1.02516 | .007 | -4.7964 | -.7518 |
| | F | -2.99342* | 1.14440 | .010 | -5.2509 | -.7359 |
| | HRM | -1.45833 | 1.31940 | .270 | -4.0611 | 1.1444 |
| | M | -1.54167 | 1.15378 | .183 | -3.8177 | .7344 |
| | SCM | -3.41912* | 1.16418 | .004 | -5.7156 | -1.1226 |

*The mean difference is significant at the 0.05 level.

Majors: A, Accounting; BA, Business Administration; F, Finance; HRM, Human Resources Management; M, Marketing; SCM, Supply Chain Management; O, Other

Appendix Table 2. Post-Hoc Tests for Quizzes

| I (Major) | J (Major) | Mean Difference (I-J) | Std. Error | Sig. | 95% CI | |
|--------------|--------------|-----------------------------|---------------|------|----------------|----------------|
| | | | | | Lower Bound | Upper Bound |
| A | BA | .16746 | .14578 | .252 | -.1201 | .4550 |
| | F | .48536* | .21065 | .022 | .0698 | .9009 |
| | HRM | .46699 | .28794 | .107 | -.1010 | 1.0350 |
| | M | .46533* | .21517 | .032 | .0409 | .8898 |
| | SCM | .74824* | .22012 | .001 | .3140 | 1.1824 |
| | O | -.07662 | .30342 | .801 | -.6751 | .5219 |

| | | | | | | |
|-----|-----|----------|--------|------|---------|--------|
| BA | A | -.16746 | .14578 | .252 | -.4550 | .1201 |
| | F | .31789 | .21504 | .141 | -.1063 | .7421 |
| | HRM | .29953 | .29117 | .305 | -.2748 | .8739 |
| | M | .29787 | .21948 | .176 | -.1351 | .7308 |
| | SCM | .58077* | .22433 | .010 | .1383 | 1.0233 |
| | O | -.24408 | .30648 | .427 | -.8486 | .3605 |
| F | A | -.48536* | .21065 | .022 | -.9009 | -.0698 |
| | BA | -.31789 | .21504 | .141 | -.7421 | .1063 |
| | HRM | -.01836 | .32848 | .955 | -.6663 | .6296 |
| | M | -.02003 | .26701 | .940 | -.5467 | .5067 |
| | SCM | .26288 | .27101 | .333 | -.2717 | .7975 |
| | O | -.56197 | .34213 | .102 | -1.2369 | .1129 |
| HRM | A | -.46699 | .28794 | .107 | -1.0350 | .1010 |
| | BA | -.29953 | .29117 | .305 | -.8739 | .2748 |
| | F | .01836 | .32848 | .955 | -.6296 | .6663 |
| | M | -.00167 | .33140 | .996 | -.6554 | .6521 |
| | SCM | .28124 | .33464 | .402 | -.3789 | .9413 |
| | O | -.54361 | .39445 | .170 | -1.3217 | .2345 |
| M | A | -.46533* | .21517 | .032 | -.8898 | -.0409 |
| | BA | -.29787 | .21948 | .176 | -.7308 | .1351 |
| | F | .02003 | .26701 | .940 | -.5067 | .5467 |
| | HRM | .00167 | .33140 | .996 | -.6521 | .6554 |
| | SCM | .28291 | .27454 | .304 | -.2586 | .8245 |
| | O | -.54194 | .34494 | .118 | -1.2224 | .1385 |
| SCM | A | -.74824* | .22012 | .001 | -1.1824 | -.3140 |
| | BA | -.58077* | .22433 | .010 | -1.0233 | -.1383 |
| | F | -.26288 | .27101 | .333 | -.7975 | .2717 |
| | HRM | -.28124 | .33464 | .402 | -.9413 | .3789 |
| | M | -.28291 | .27454 | .304 | -.8245 | .2586 |
| | O | -.82485* | .34804 | .019 | -1.5114 | -.1383 |
| O | A | .07662 | .30342 | .801 | -.5219 | .6751 |
| | BA | .24408 | .30648 | .427 | -.3605 | .8486 |
| | F | .56197 | .34213 | .102 | -.1129 | 1.2369 |
| | HRM | .54361 | .39445 | .170 | -.2345 | 1.3217 |
| | M | .54194 | .34494 | .118 | -.1385 | 1.2224 |
| | SCM | .82485* | .34804 | .019 | .1383 | 1.5114 |

*The mean difference is significant at the 0.05 level.

Majors: A, Accounting; BA, Business Administration; F, Finance; HRM, Human Resources Management; M, Marketing; SCM, Supply Chain Management; O, Other

NSSE as an Institutional Assessment Tool: Increasing Response Rates and Student Awareness

Angela Ward, Laura Snelson, Nikole Higgins, David Anderson

Utah Valley University

Abstract

A 2014 webinar for the National Survey for Student Engagement (NSSE) reported a lack of empirical information regarding the extent to which campus promotional campaigns impacted survey response rates. On the other hand, anecdotal evidence was reported indicating that promotional campaigns positively impacted response rates. At Utah Valley University (UVU), NSSE has been administered for the past 6 years. Administrators at UVU are interested in using NSSE data to inform leaders at lower-level units (department, college, and major). To achieve the desire level of student participation and maintain reliable and valid results, the Office of Institutional Research and Information (IRI) set out to evaluate the efficacy of general campus promotional activities designed to increase student awareness and consequently survey response rates. Higher-level response rates at lower-level administrative units may generate reliable and valid results that can accurately impact macro-level policy implications and drive informed decision made by stakeholders. The promotional activities did

not seem to increase awareness, but these results are not conclusive because of the preliminary nature and short period of promotional material exposure.

Introduction

For many years, a survey's response rate was viewed as an important indicator of survey quality. Many observers presumed that higher response rates assure more accurate survey results. But because measuring the relation between nonresponse and the accuracy of a survey statistic is complex and expensive, few rigorously designed studies provided empirical evidence to document the consequences of lower response rates, until recently. This study will contribute to the literature by gaining insights regarding the value of in-house promotional campaign impacting low survey response rates.

Methods

Promotional campaign

The general campus promotion processes aimed at increasing student awareness included an exploratory phase, implementation of intervention (advertisements), and follow-up assessment. We began by designing a simple, informative advertising-banner, followed by conducting focus groups to evaluate the extent to which the proposed advertising-banner's design conveys information about NSSE's objective and what NSSE is. Based on student feedback from focus groups, ads were redesigned to reflect focus group suggestions.

Student awareness

To learn about the degree of campus student awareness, we undertook random student interviews. We interviewed students who were on campus during spring semester during lunch hour. Our goal was to interview 80 students at random. Three research assistants participated conducting interviews. Research assistant sampled students from areas with high traffic. Our target was to interview 50% male and 50% female students. Age was not a variable taken into account. Most students were typical college-age students.

Banner development

The promotional campaign included primarily physical and digital banners of different sizes in high traffic campus locations and on the main university website during the administration of NSSE. To assess the effectiveness of our NSSE awareness campaign we conducted a survey with a random sample of about 10,000 UVU students several weeks after the implementation phase. Additionally, campus-wide interviews and focus groups were used to evaluate any increase in student awareness of the NSSE survey. Finally, UVU faculty were invited to participate via two email invitation letters signed by the Academic Vice-President. The letter asked faculty to announce in their classrooms that students should have received an invitation from NSSE to participate in the survey. A list of students that were sampled to participate in NSSE was included as part of the invitation letter to faculty. Faculty were not expected to send individual invitation emails to NSSE-selected participants. Faculty members were provided with student names for the sole purpose of informing students who may ask whether or not they are part of the NSSE sample. To measure the effectiveness of faculty participation on student response rates, we conducted a survey with a random sample of full and part-time faculty that teach during spring semester, right after the last NSSE student reminder went out. We expected to observe response rates higher than have been seen over the past five years at our university. We also anticipated higher campus-wide awareness of the NSSE survey following the intervention.

UVU campus survey participants received an electronic version of a survey to assess the effectiveness of the NSSE banners at increasing survey awareness and survey response rates. This email survey was sent to students prior to and after banner advertisement launch. The survey took between 2 and 5 minutes to complete since it only included 5 questions.

Randomly selected interviewee participants were asked a set of four questions before and after advertisement banner launch aimed at identifying what the acronym NSSE means, whether they have seen the NSSE logo in relation to a survey before, what year are they in college, and whether they took the NNSE survey before. The interviews took 2 to 3 minutes to complete.

Faculty participants received an electronic survey with three questions intended to measure: the level of faculty participation by noticing they received an invitation letter from the academic vice-president inviting them to announcing the NSSE survey in their classrooms, the deleting of the email, the ignoring of the email, whether

the list of student provided as part of the invitation letter was useful to inform students where to go, what to do to take the NSSE survey, and the extent to which students were interested in learning about of being part of the NSSE sample.

Literature on Response Rates

Institutions of higher education rely heavily on survey data to make data driven decision making. Survey researchers have long assumed that the best way to obtain unbiased estimates is to achieve a high response rate. For this reason, the literature on survey methods is rife with best practices and suggestions to improve survey response rates. NSSE asserts that depending on institution size as few as 25 to 75 respondents appeared to provide reliable institution-level estimates for most institutions (Fosnacht et al., p.22). Similarly, the NSSE response rate FAQ asserted that as few as 50 students could provide dependable group estimates of student engagement. However institutions analyzing subpopulations of students (for example, using NSSE's Major Field Report) generally should collect data from as many respondents as possible so that each subgroup is adequately represented. NSSE also recommends that institutions benchmark their response rates in relation to peer institutions with similar enrollments. Institutions with larger enrollments generally see lower response rates (Fosnacht et al., p. 22), but they enjoy a higher degree of confidence in estimates due to the sheer number of respondents. The literature on response rates indicates that high response rates are no guarantee of data quality, nor does a low response rate automatically mean survey results are biased unless non-respondent's level of engagement is significantly different from that of respondents. Another NSSE suggestion is to consider other data quality indicators besides response rates such as respondent count and sampling error, which are included in the NSSE report. They provide several components of data quality.

Studies conducted in recent years have concluded that the expense of increasing response rates frequently is not justified given the difference in survey accuracy. For instance, findings reported by Visser et al. (1996) showed that surveys with lower response rates (near 20%) yielded more accurate measurements than did surveys with higher response rates (near 60% or 70%). Similarly, Keeter et al (2006) compared results of a 5-day survey (with a 25% response rate) with results from a more rigorous survey conducted over a much longer period and achieving a higher response rate of 50%. In 77 out of 84 comparisons, the surveys yielded results that were statistically indistinguishable.

Background

The North West Commission of Colleges and Universities (NWCCU) evaluation committee recommended that UVU conduct learning outcomes assessment to demonstrate program improvements based upon analysis of outcomes assessment data for all instruction programs (Policy 2.2 and Standard 2.B). Since programs use two distinct direct and indirect measures of student outcome assessment, the office of IRI at UVU aims at spreading throughout the campus community (academic and non-academic programs) the value of creating a culture of assessment. UVU currently administers the NSSE survey to assess student level of engagement in and out of class of its freshmen students and graduating seniors. Two years ago, the UVU leadership launched a strategic planning campaign campus wide. This campaign was aimed at establishing a culture of assessment and in so doing in order for all academic and non-academic programs to comply for planning, budget, and accountability (PBA) requests. Departments and programs should provide supporting data-driven evidence to demonstrate level of performance on their pre-identified intended outcomes. Hence, the need for college deans to use data from lower-level units (college, department, major). The purpose of this research is twofold: First, increasing student awareness about the university culture of assessment, and more specifically increasing student awareness about assessing levels of student engagement in and out of class via NSSE may translate into increasing students' perceptions about UVU's culture of assessment. Second, as a result of student awareness of UVU's culture of assessment the office of IRI may observe an increase in student response rates via the development of a NSSE promotional campaign. A 2014 webinar for the NSSE reported a lack of empirical information regarding the extent to which campus promotional campaigns impacted survey response rates. We expect to observe response rates higher than what has been seen over the past five years at our university. We also anticipate higher campus-wide awareness of the NSSE survey after the intervention. Anecdotal evidence suggests promotional campaigns result in increased response rates. At UVU, NSSE has been administered for the past 6 years. Although our institution has large enrollment size, our response rates lag behind our peers. Administrators at UVU are interested in using NSSE results to inform leaders at lower-level units (department, college, and major). To achieve the desire level of student participation and maintain reliable and valid results, the office of IRI designed a study to investigate the efficacy of general campus promotional activities designed to increase the level of NSSE response rates. Higher-level response rates at lower-

level units may increase the reliability of results and impact macro-level policy implications and drive informed decision making at the administrative level.

NSSE is administered by the Center for Postsecondary Research at Indiana University Bloomington. All first-year (FY) students and graduating seniors (SR) are asked to participate. Students are directed to a web-based version of the survey. Following the initial contact early in the spring, NSSE staff conducts various follow-up activities with non-respondents over a three month period.

Methodology

NSSE promotional campaign

The general campus promotion processes included an exploratory phase, implementation of intervention (advertisements), and follow-up assessment. We began by designing a simple, informative advertising-banner, followed by conducting focus groups to evaluate the extent to which the proposed advertising-banner's design conveyed the intended NSSE message, what NSSE is, and the level of student awareness regarding the NSSE survey.

Advertisements

Ads were redesigned to reflect focus group suggestions. Focus groups suggestion results are not presented in this study. Next, we conducted a general promotional campaign that included the display of physical and digital banners of different sizes in high-traffic campus locations and on the main university website during the administration of NSSE. To assess the effectiveness of our NSSE awareness campaign, we conducted a survey with a random sample of about 10,000 UVU students several weeks after the implementation phase. Additionally, campus-wide interviews and focus groups were used to evaluate any increase in student awareness of the NSSE survey. Although the initial proposal indicated that we would include an evaluation section of the extent to which faculty participated assisting with NSSE. This report will not contain results on this aspect because of a lack of resources to conduct such evaluation. This report provides only a description of the way faculty participated. Faculty was asked via two email invitation letters signed by the University Academic Vice-President to invite students enrolled in their classes to participate in the NSSE survey. In this report, we do not include results of the extent of faculty participation. The first "invitation" letter to faculty

asked faculty to encourage students to participate in NSSE by announcing it in class. The second "thank you" letter to faculty contained a list of students who were part of NSSE sample and asked faculty to encourage their students to participate in NSSE and to use the list to facilitate student's inquiry of whether they are or not part of the sample. The "thank you" letter stated that due to NSSE IRB regulations students cannot be contacted directly by faculty and that the extent of their help would be to only announce NSSE in their classrooms. Faculty were not expected to send individual invitation emails to NSSE-selected participants. Faculty members were provided with student names for the sole purpose of informing students who may ask whether or not they are part of the NSSE sample. Our plan to measure the impact of faculty participation on student response rates was to conduct a survey with a sample population of full and part-time faculty that teach during spring semester, right after the last NSSE student reminder went out. Our expectations were to observe response rates higher than what has been seen over the past five years at our university.

Student awareness

We anticipated higher campus-wide student awareness of the NSSE survey after the intervention. To assess this outcome we proceeded to conduct interviews that consisted of three questions: (1) Have you seen this logo before? (2) Did you hear about NSSE? (3) Do you know what the acronym NSSE means? (4) Have you taken the NSSE survey before? (5) What is your class level?

The interview process was conducted by three research assistants, and a total of 80 individuals were interviewed.

To assess the effectiveness of campus awareness about NSSE, the office of IRI conducted a survey as part of its omnibus survey to a sample random of about 10,000 UVU male and female students, their ages ranging from 17 to 65 years.

Results

Table 1 shows the distribution of student's NSSE survey response rates for the last eight years. In 2008 there were 193 first-year and 560 senior participants. The response rate for first-year students was 17% and that for seniors was 31%. In 2009, UVU experienced the highest response rate compared with all other years. Thereafter, response rates for first-year and senior students declined slightly, reaching response

Table 1: UVU First Year and Senior Student's NSSE Survey Response Rates

| Year | Respondent Count* | | Response Rate (%) | |
|------|-------------------|-------|-------------------|----|
| | FY | SR | FY | SR |
| 2015 | 331 | 1,044 | 13 | 19 |
| 2014 | 354 | 998 | 16 | 20 |
| 2013 | 656 | 1,047 | 15 | 24 |
| 2012 | 359 | 591 | 22 | 29 |
| 2011 | 550 | 452 | 14 | 22 |
| 2010 | 479 | 606 | 17 | 28 |
| 2009 | 812 | 1,180 | 32 | 47 |
| 2008 | 193 | 560 | 17 | 31 |





rates of 13% and 19%, respectively. It may be that due to the incorporation of technology there has been a survey fatigue and that students are not as responsive as when surveys were not as popular as they are nowadays.

Findings on Student Awareness from Survey

Results regarding student awareness were not appropriately designed. We failed to measure initial awareness level prior to the launch of the campaign. Results in this section include findings of student awareness after the launch of the promotional campaign. This practice impedes obtaining true impact of the promotional campaign. IRI plans to conduct a similar assessment during Spring 2016 to obtain a more accurate result regarding NSSE student awareness. Current results on student awareness are shown in Table 2. The campus surveyed a total of about 10,000 UVU student from which 505 responded to the NSSE section. The question students were asked was “to what extent are you aware of the NSSE survey for college freshmen and seniors? Three hundred ninety-one (77%) of participants indicated they were completely unaware of the NSSE survey for college freshmen and seniors. Thirteen respondents, which represents 3% of participants, said were highly aware of the NSSE survey.

Findings on Student Awareness from Interviews

Results from initial awareness level via student interview reflect that student awareness has increased minimally. Of a total of 80 students, 79 indicated that they did not know about NSSE at all. Most students associated NSSE with the Loch Ness Monster.

| Table 2: Q1. To what extent are you aware of the NSSE survey for college freshmen and seniors? | | | | |
|---|--------------------|---|----------|------|
| # | Answer | | Response | % |
| 1 | Completely Unaware |  | 391 | 77% |
| 2 | Somewhat Unaware |  | 53 | 10% |
| 3 | Somewhat Aware |  | 48 | 10% |
| 4 | Highly Aware |  | 13 | 3% |
| | Total | | 505 | 100% |

Findings on Student Awareness from Survey

Table 2 shows the distribution of responses about level of student awareness. Of a total of 505 respondents to the question, 77% indicated they were completely unaware, 10% were somewhat unaware, 10% were somewhat aware, and 3% were highly aware.

Findings on awareness due to various sources of promotional campaign elements are as follows. Table 3 shows results on “How did you hear about/learn about the NSSE Survey?” Seventy percent of respondents to this item indicated they learned about NSSE via email, indicating that most received an email invitation from NSSE directly.


















| Table 3: Q2. How did you hear about/learn about the NSSE Survey? (mark all that apply) | | | | |
|---|---|---|----------|----|
| # | Answer | | Response | % |
| 1 | Digital signs around campus |  | 11 | 10 |
| 2 | Posters hanging in the hall |  | 5 | 4 |
| 3 | I received an email about it |  | 79 | 70 |
| 4 | A faculty member/professor told me about it |  | 15 | 13 |
| 5 | I've taken it before |  | 19 | 17 |
| 6 | I'm not sure |  | 15 | 13 |
| 7 | other |  | 9 | 8 |

Table 4 displays responses on the open-ended question that asked in what other ways students received NSSE information.

| Table 4: Q2.g What other source helped you learn about NSSE: |
|--|
| Other |
| Advisor |
| Orientation Leader |
| I was told to take it |
| My mom told me |
| Approached by students giving out candy and informing about it |
| I think I've just heard about it |
| Work |
| 15 emails from UVU |
| Too many emails |

Student Awareness due to In-house Built Promotional Campaign

Table 5 displays six options from which students were asked whether any of these options help them learn about NSSE. Responses to this question are spread out. Twenty percent of respondents to this question indicated they noticed picture number 1 most.

| Table 5: Q.3 Please mark any signs you have seen on campus this semester. (mark all that apply) | | | | |
|---|---|---|----------|-----|
| # | Answer | | Response | % |
| 1 |  |  | 102 | 20% |
| 2 |  |  | 55 | 11% |
| 3 |  |  | 84 | 17% |
| 4 |  |  | 44 | 9% |
| 5 | I haven't seen any of these |  | 313 | 62% |
| 6 | I don't attend the main Orem campus |  | 37 | 7% |

Recommendations

The statistical analysis design for future studies should include a pre- and post-assessment of student awareness using both surveys and interviews this may help obtain a more accurate measure of the impact of the promotional campaign.

The value of triangulation of results ought to be of importance. It might be especially helpful to consider at least two campus focus groups as well as random campus interviews on NSSE awareness.

To obtain a true measure of student response rates in future studies it may be necessary to evaluate level of response rates at lower-level units (College, department, major) to see whether the campaign assisted in increasing response rates at these levels.

Conclusions

True effects of promotional campaign are difficult to demonstrate. A better study design with more concrete measures of initial and final assessments may lead to better results.

It is uncertain yet whether student survey response rates will increase. A follow-up study is suggested to find out whether the effect of monetary incentive or a professionally developed promotional campaign may have clear results.

References

Fosnacht, K., Sarraf, S., Howe, E., and Peck, L. (2013). *How important are high response rates for college surveys?* Paper presented at the Annual Forum of the Association for Institutional Research, Long Beach, CA.

Keeter, S., Kennedy, C., Dimock, M., Best, J., and Craighill, P., Gauging the impact of growing nonresponse on estimates from a national RDD telephone survey. *Public Opin Q* (2006) 70 (5): 759-779

National Survey of Student Engagement. NSSE Response Rate FAQ. 2016. Retrieved January 28, 2016, from http://nsse.indiana.edu/pdf/Resp_Rate_FAQ.pdf.

Visser, P.S. Mail surveys for election forecasting?: An Evaluation Of The Columbus Dispatch Poll. *Public Opin Q* (1996) 60 (2): 181-227

Hybrid Wind and Solar Electric Power System

Doran Baker and Gene Ware

Utah State University

Abstract

Utah State University students designed a hybrid wind/solar power network. The approach is to integrate electric power from a three-panel solar array and from a vertical-axis wind turbine (VAWT). Typically, the wind is harvested for about eight hours after midnight and the solar irradiance for about six to eight hours during daylight. The harvested electric energy is stored in chemical batteries. The 600-watt, relatively low-power system is intended primarily for education and demonstration purposes.

Introduction

Utah State University students and mentors designed, assembled, and tested an electrical power system using wind and solar renewable energy. The wind power subsystem employs a roof-mounted Darrieus vertical-axis wind turbine (VAWT). The solar power subsystem employs a roof-mounted Thunderbolt Magnum multiple-panel silicon solar cell array.

Wind Turbine Generation System

The subsystem for wind turbine electricity generation is shown in Figure 1. The wind turbine, pictured in the illustration, is a type UGE 600-watt unit procured from Beijing Urban Green Energy Co., Ltd. The three blades, symmetrically mounted on a vertical axis, are helically shaped so the turbine will respond to moving atmosphere from any azimuthal direction. The wind power harvested can be calculated from

$$P = \frac{1}{2} \eta \rho S v^3$$

where η is the efficiency of wind to electrical energy conversion, ρ is the air density at the altitude where the turbine is situated, S is the effective cross-sectional swept area of the blades, and v is the wind velocity. It is noted that the output power is proportional to the cube of the speed of the wind. The operating range is from a cut-in wind speed of 3 meter/second up to 25 meter/second. The maximum rated power is 640 watts and the upper limit on wind speed is 56 mph.

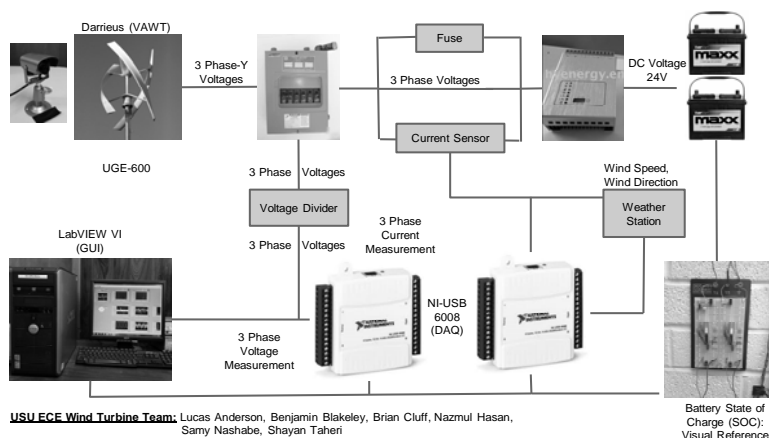


Figure 1. Wind power subsystem.

Compared with the more common three-blade horizontal-axis wind turbine, the Darrieus helical vertical axis turbine has slower blade-tip speeds. Consequently, the audible noise level is less than 27 dB at 3-meter distance, and bird safety issues have rarely been of concern. Helical wind turbines can be placed on rooftops rather than towers, and no tail-fan is required for orientation in the optimal direction. The USU turbine is mounted on top of the Dean F. Peterson,

Jr. Engineering Laboratory Building, which is located approximately 2 km from the mouth of Logan Canyon. Typically, the daily wind is channeled from the canyon to build up near midnight and lasting eight hours.

The size of the windmill is 1.6 by 1.25 meters and the gross weight of the unit is 60 kg. The generator is a permanent magnet direct-drive UGE VAWT alternator. This unit outputs three phases of ac voltages in a wye configuration, each of which is limited to ± 12 volts for safety, as seen in Figure 2. Each of the output lines is fused with Home 12L100 circuit breakers, and each current is monitored. A Graphical User Interface (GUI) written in LabVIEW VI is used to display all three sets of voltages and currents on the Dell Workstation Monitor (Fig. 2). A National Instruments NI-USB 6008 (DAQ) Datalogger is used for data control and intermediate data storage.

An inverter is used to provide 12 VDC for energy storage in PbS batteries. The battery charge status is monitored with a specially designed circuit.

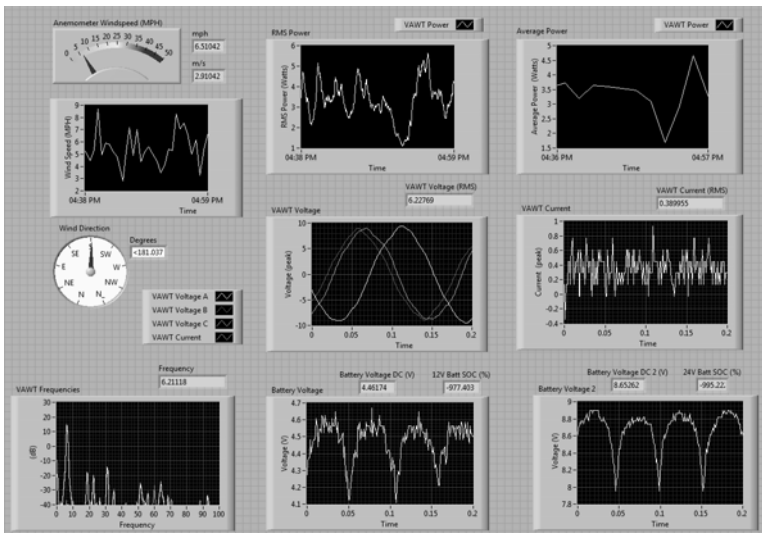


Figure 2. Wind power output display.

Solar Array Power System

The subsystem for the solar irradiance to electrical power is illustrated in Figure 3. The solar array is pictured to comprise two sets

of three panels each mounted on the roof of the Dean F. Peterson, Jr., Engineering laboratory Building on the USU campus. The array is located at approximately 41.7 degrees north latitude and -112 degrees west longitude. The solar panels were procured from Thunderbolt Magnum Solar and manufactured by Sunforce.

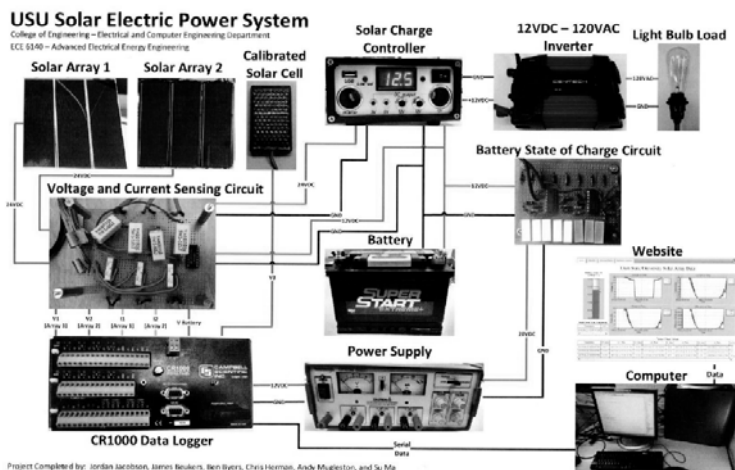


Figure 3. Solar power subsystem.

The solar array is composed of a total of 174 intrinsic silicon semiconductor solar cells of vertically elongated rectangular shape. This array with two modules of three panels each is rated at 14.5 volts dc and can deliver a maximum of just under 100 watts. The voltage and current of each of the two modules are monitored using voltage and current sensing circuits. The electrical power is routed through a solar charge controller to energy storage. This controller has many dc voltage ports to facilitate various types of loads to be connected.

The solar power harvested can be calculated from

$$P = \eta SH$$

where η is the efficiency of solar to electrical energy conversion, S is the active area of the array, and H is the solar irradiance. The electric power is dc but may be transformed to ac using an inverter as illustrated on Figure 3.

The solar power system uses a Campbell Scientific SR 1000 Datalogger to collect, process, and temporarily store data as needed. The Datalogger uses both differential and single-ended channels to

collect measurements, and the data are passed to a workstation for display and storage. A Graphical User Interface (GUI) and a webpage interface were designed so that the outputs and metadata parameters could be displayed on a monitor as shown in Figure 4. Campbell Scientific RTMC Prosoftware was employed.

Figure 4 shows a typical daily output as displayed on the computer monitor. The four subpanels of the display show each of the following as a function of time: dc voltage, dc current, power, and efficiency. Also displayed is the status of charge of the storage battery. Further, available upon command is the weekly output of the four parameters.

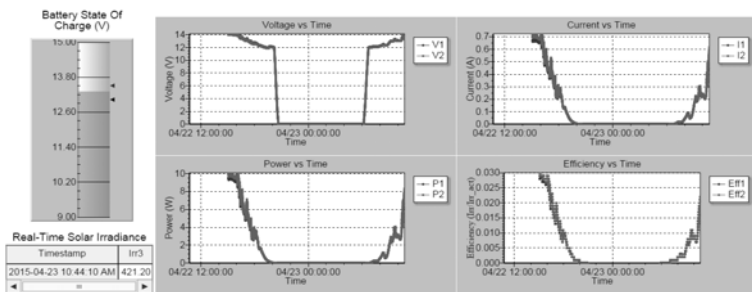


Figure 4. Solar power output display.

Electric energy storage received from solar daytime irradiance conversion is achieved using parallel 12-volt dc PbS batteries. A battery state of charge circuit was used to monitor the real-time status of energy storage.

Acknowledgments

The presenters recognize the essential contributions of the students under team leaders Lucas Anderson on the wind-powered subsystem and Jordan Jacobson on the solar-powered subsystem. The student team members on wind were Benjamin Blakeley, Brian Cluff, Nazmul Hasan, Sammy Nashabe, and Shayan Taheri. The students on the solar team were James Beukers, Chris Herman, Ben Byers, Su Ma, and Andy Mugleston. Paul Campbell and Cameron Madsen of Campbell Scientific provided valuable assistance plus hardware and software. Bidisha Biswas, Shayln Scott, and Heidi Harper assisted in organizing and operating the class project and laboratories.

References

Anderson, L., B. Blakeley, B. Cluff, N. Hasan, S. Nashabe, S. Taheri, *Vertical Axis Wind Turbine Generation System*, Final Report, Utah State University, April, 2015.

Baker, D.J., *Electrical Energy Engineering*, 3rd ed., Utah State University, Logan, UT, 2012.

Helical Wind Turbine, Helical Wind Turbine Design and Advantages, *Whirlopedia*, 2014. Retrieved April 15, 2015, from <http://www.whirlopedia.com/index.php/helical-wind-turbine/>

Jacobson, J., J. Beukers, C. Herman, B. Byers, S. Ma, A. Mugleston, *Solar Electric Power System*, Utah State University, Final Report, April, 2015.

Patel, M.R., *Wind and Solar Power Systems*, 2nd Ed., CRK Press; 2006.

Sage, A.P., J.E. Armstrong, Jr., *Introduction to Systems Engineering*, Wiley, New York, 2000.

Thunderbolt Magnum Solar, 45 Watt Solar Panel Kit 68751, Camarillo, CA 2011. Retrieved April 15, 2015, from <http://manuals.harborfreight.com/manuals/68000-68999/68751.pdf>

Wind Turbine System CE, 600 Watt Type VAWT 6000-UGE, Beijing Urban Green Energy Co., Ltd, 2004.

Space Dynamics Laboratory: An Unexpected Success

Brian Simons and Doug Lemon

Utah State University

Abstract

Utah State University's Space Dynamics Laboratory (SDL) has made an impact on an international scale through its history of developing crucial aerospace technologies. Despite its remote location in the Cache Valley, the space program has grown continually for more than six decades. SDL has done so by successfully completing important projects for government and civilian contractors. The impact of these programs has led to more contracts and expanded engineering capabilities. SDL has shifted its focus as needed to meet current customer needs. SDL had its early roots in upper atmospheric research, while today its key capability is electro-optics systems and geospatial measurements. Its global impact is not limited to technological innovation but extends to include social and political impact. SDL is not simply a company in Cache Valley that provides employment and student education, but rather has a rich history of making technological achievements with a global ramifications.

Utah State University's (USU) Space Dynamics Laboratory (SDL) is a research organization that has been on the forefront of

technological aerospace advancements for six decades. SDL performs contracted aerospace engineering work for both private and government customers for a variety of applications, including military, science, and industrial contracts. SDL brings an annual revenue in the range of \$60 million, while employing approximately 500 individuals, including 100 students. SDL is headquartered in the Jake Garn Building near the USU campus (Figure 1). SDL facilities in Logan currently comprise nine buildings, totaling more than 220,000 square feet. SDL also has seven strategically located field offices from Los Angeles, CA, to Bedford, MA.¹



Figure 1. SDL Jake Garn Building (B. Simons).

SDL's primary area of expertise is in electro-optics, utilized in a wide range of applications, although the Laboratory is diverse in its capabilities and projects. SDL work has included launching sounding rockets for the purpose of atmospheric study, building satellites both small and large, engineering sensors for NASA's Space Shuttle Program, placing instrumentation on the International Space Station, teaming on joint aerospace projects with Russian engineers, and developing advanced reconnaissance technology for the U.S. military. SDL began with the task of modeling the physical composition of the upper atmosphere and has recently completed the task of mapping the universe with an advanced telescope.

Utah's Cache Valley is a seemingly unlikely location for a space research organization of world renown. Logan is not situated near any

¹"Locations." Space Dynamics Laboratory. Last modified 2015.
<http://www.sdl.usu.edu/company/locations>.

major urban industrial complex, nor is it near a space-oriented Air Force Base or NASA research center. Typically, government aerospace contractors locate themselves geographically around such bases and research centers, forming a sort of cluster effect. Proximity to such large contracting institutions has obvious benefits. Moreover, many of these clusters are located on coastal seaboards and near large airports. Northern Utah is landlocked with no significant rivers, and the nearest major airport is located two hours away. The first source of contract work for early SDL predecessor labs came from the Air Force Cambridge Research Center in Boston, MA.

SDL stayed relevant as an aerospace research institution long past its initial inception for the purpose of upper atmospheric studies. SDL has done so through its ability to adapt to customer needs and to stay connected on a national level with the right people who understand the direction of the aerospace industry. Over the years, SDL has increased in recognition and stature from both sponsors and colleague institutions. To assist the rising status of the organization, SDL formed a Guidance Council, an independent group of influential people and experts who lend an outside perspective and contacts connected to the aerospace industry. Members of the Guidance Council have included retired high-ranking military officers, senators, astronauts, and scientists, led by former NASA Administrator and emeritus University of Utah President James Fletcher (Figure 2).²



Figure 2. 2014 SDL Guidance Council, left to right: Lynn Heninger, Gen. (Ret.) Gary Schnelzer, Col. (Ret.) Gary Payton, Sue Payton, David Lee, RADM (Ret.), Elizabeth Young, Sen. (Ret.) Jake Garn, and Gen. (Ret.) Bruce Carlson (SDL Archive).

²Lemon, 77.

SDL's most recent and publicized success was the WISE sensor built under sponsorship of NASA (Figure 3). WISE was built for the purpose of providing an updated mapping of the universe; echoing a similar project that was previously completed by NASA in 1983. The WISE satellite system was implemented over the course of a decade and was launched into orbit via rocket in December 2009. Key to obtaining high-resolution images of the celestial universe was maintaining an extremely cool temperature for the infrared detectors. WISE was kept below -429 degrees Fahrenheit for a period of five years, during which time more than 4 million high-resolution images were obtained.

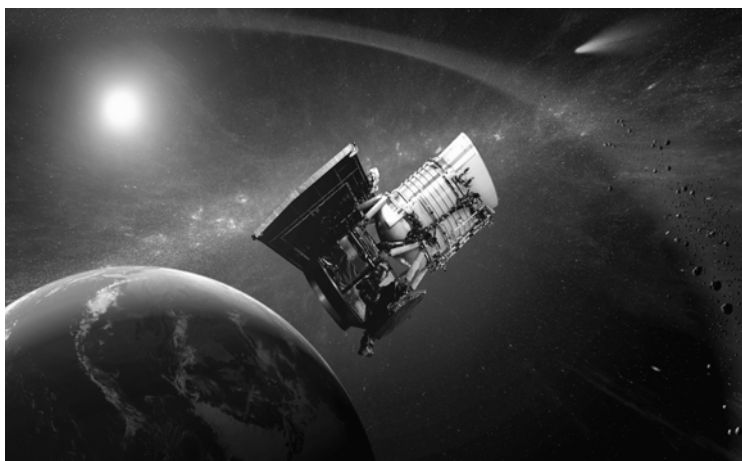


Figure 3. WISE concept art (NASA).

During its five-year mission, WISE mapped the universe 1.5 times and discovered 34,000 asteroids, 17 comets, and over 500 brown dwarf stars. The impact of WISE cannot be understated, as its survey of the universe was at a resolution hundreds of times greater than the previous all-sky survey done in 1983 (Figure 4).³

The Utah space program was born in the late 1940s following World War Two. The University of Utah, with the intent to expand its engineering and physics research programs, recruited Dr. Leon Linford from MIT. Linford founded the Upper Air Research Project (later

³Lemon, 127-129, 151-153.

renamed the Upper Air Research Laboratory (UARL)), whose focus was measuring the high-altitude atmosphere using captured German V-2 rockets. The UARL was the first of SDL's predecessor laboratories. Linford, through his contacts made with the Air Material Command while at MIT, secured the University of Utah's first space research

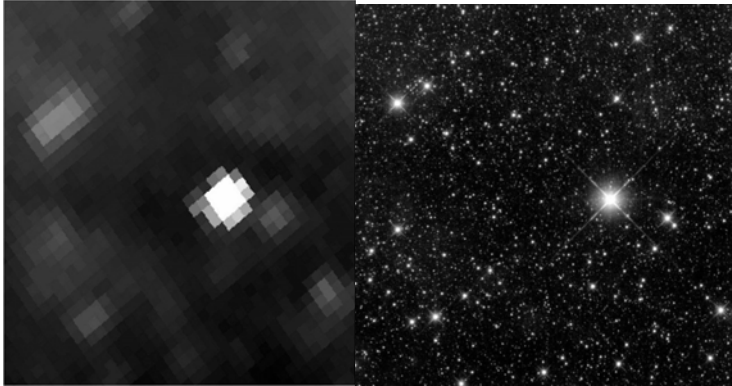


Figure 4. 1983 Star cluster image and modern WISE photo of same cluster (NASA).

contract. Government demand for knowledge of the atmosphere was heightened in 1957 following the Soviet launch of *Sputnik 1*, as the capability to put objects on orbit opened up new possibilities for aggression from space.⁴

Dr. Doran Baker was recruited by Professor Larry Cole and Dean D.F. Peterson, Jr. to establish a space research program at USU in 1959. Baker founded the Electro-Dynamics Laboratories (EDL) at USU. While UARL focused on the physical chemistry of the atmosphere, the EDL focused on measuring the infrared spectra of the atmosphere, creating a synergistic relationship between the two Utah laboratories.

Dr. Kay Baker became Associate Director of UARL in 1967 and ran the laboratory with Director Obed Haycock. USU expanded its space research program under the leadership of Dr. Farrell Edwards by bringing the University of Utah space program to the USU Physics Department under the new aeronomy research lab, which was named

⁴Lemon, 7.

the Space Science Laboratory. The two labs, EDL and SSL, were merged in 1982 to form the Space Dynamics Laboratory, taking part of its name from each of the parent laboratories.⁵

A major focus of UARL/SSL and EDL through the 1970s was the firing of scientific sounding rockets into aurora from ranges in Canada and Alaska (Figures 5 and 6). An aurora was known to have a similar effect on the upper atmosphere as a detonated high-altitude nuclear weapon, although on a much smaller and less-predictable scale. The US Defense Department was concerned whether natural aurora and/or artificial nuclear events could be used to mask incoming intercontinental ballistic missiles (ICBMs). Tests were conducted to study changes in the chemistry and light spectra of the atmosphere during such anomalies. Also of importance was the characterization of rocket plumes. During times when the U.S. was not under nuclear moratorium, UARL/SSL and EDL participated in upper atmospheric nuclear testing and provided scientific data crucial to improving U.S. missile defense capabilities. Although this research was done for the purpose of developing missile defense technology, much of what is now generally known about the composition and nature of the atmosphere and auroras stems from this research conducted by SDL and its predecessor labs.⁶



Figure 5. UARL team preparing sounding rocket, Kay Baker on far right, Doran Baker of the US Air Force (Kay Baker)

⁵Lemon, 62.

⁶Lemon, 16-20.

As the Soviet threat dissipated, SDL expanded its capabilities by building the CIRRIS 1A sensor to be launched as part of NASA's Space Shuttle Program. Continuing the tradition of studying auroral events, the task of CIRRIS 1A was to measure an aurora from space (Figure 7), rather than from the ground. Sounding rockets provide only a few short moments during which they conduct measurements, offering scientists only a brief window into the makeup of an aurora. SDL broke this barrier with the CIRRIS 1A sensor. CIRRIS 1A made it possible for prolonged measurements to be taken of the upper



Figure 6. SDL firing sounding rocket into aurora on 15 January 2015. (NASA)

atmosphere from space, greatly revising dated atmospheric models, as change over time could now be brought into the equation. The CIRRIS program provided a basis for the revolutionary cryogenic cooling technology that was later further developed for use on the WISE sensor. Thus, the CIRRIS 1A instrument represented both engineering and scientific milestones. The program also demonstrated that SDL was fully capable of handling large and important NASA programs. Research with global ramifications was conducted using instruments engineered, calibrated, and tested in Logan, UT.⁷

⁷Lemon, 91-94.



Figure 7. CIRRIS 1A view of aurora from cargo bay of Space Shuttle (NASA)

As SDL took on larger and more sensitive contracts, a degree of autonomy separate from the university was required for classified programs. To meet this need, SDL was placed under the USU Research Foundation (USURF) with its own Board of Directors. The honorable Glenn J. Mecham (Figure 8) was appointed Chair of the USURF Board, which was renamed on his suggestion the Board of Trustees for liability reasons. Mecham, an attorney by profession and was an exceptionally popular and productive mayor of Ogden, led the status of SDL to a new level.⁸



Figure 8 Glenn Mecham, former Ogden mayor and USURF Board of Trustees Chair (USU Special Collections Archive).

⁸Lemon, 57.

SDL has also made an impact on the global political scene, in conjunction with contributing to an overall body of scientific knowledge. In a turn of events following decades of research completed to combat the Soviet threat, SDL led the way in a collaborative effort between Russia and the U.S. SDL's Guidance Council facilitated such an opportunity. A priority for the United States and the newly formed Russian Federation was a collaboration on a joint weather detection satellite system, titled RAMOS (Russian-American Observation Satellites). The RAMOS program designated that two satellites, one Russian and one American, would orbit in tandem, with their sensors correlated to view the same area simultaneously (Figure 9). The two satellites would share data only, while no proprietary technology would be exchanged between the two nations. Using RAMOS, if an anomaly occurred, it would be detected by both satellites, offering mutually shared information about any rash thrusts by rogue nations.

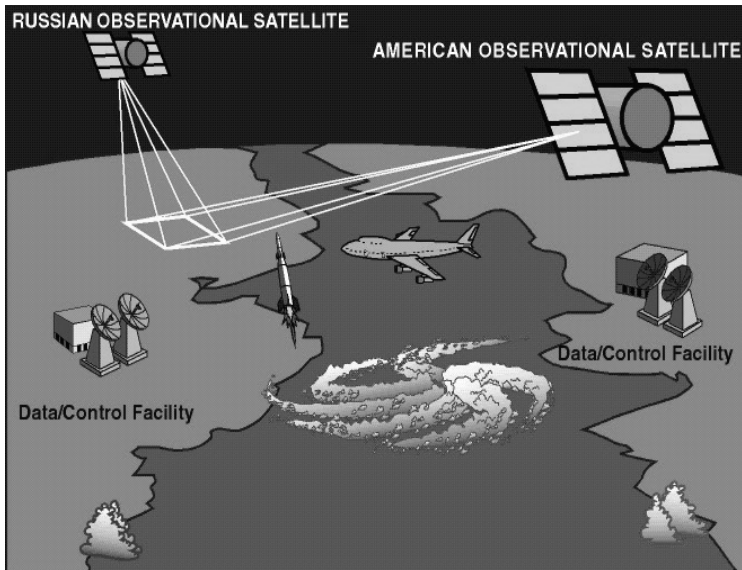


Figure 9. RAMOS concept (SDL Archive).

The RAMOS program came with lots of red tape, as both sides had to obtain permissions and approvals from their respective governments. SDL personnel were able to tour Russian facilities, and Russian scientists and engineers were able to tour SDL facilities and attend planning meetings at USU. The RAMOS program operated for a decade, but unfortunately was cancelled in 2004 as part of budget cuts

and shifts in government funding following the 9-11 terrorist attacks. The joint Russian-American RAMOS endeavor was an appropriate interlude to the military arms race.⁹

SDL and its predecessor laboratories have been at the forefront of aerospace research for more than six decades. During this time, the Utah space program has provided a role model for exploring the upper atmosphere and space. Major accomplishments include WISE, CIRRIIS, SABER, RAMOS, and geospatial imaging. SDL has pioneered small satellite technology, built sensors for the International Space Station, and leads the way in real-time video and data compression technology. Increased demand for SDL predecessor lab services brought about the transfer of UARL to USU leading to a subsequent merger with EDL. Growth necessitated a move off campus by SDL to expand. The impact of SDL in the world of atmospheric science and space engineering is visible in the results of projects completed by SDL, all made possible in a small farming valley in Northern Utah.

Acknowledgments

This paper is based on a draft of the upcoming book by Dr. Doug Lemon, *Journey to the Stars: A History of Utah State University's Space Dynamics Laboratory* (Logan, UT: Utah State University Research Foundation).

We would like to thank the USU College of Engineering and Space Dynamics Laboratory for funding this research. Doran and Kay Baker provided a wealth of information on this project. Thanks to all of the people who assisted in bringing the history of SDL to life.

Bibliography

Baker, Doran J., A.T. Stair Jr., Bartell C. Jensen, and M.K. Jeppesen. "Making History: The Ramos Program." *Quest: The History of Spaceflight Quarterly* 21, no. 3 (2014): 47-50.

Lemon, Douglas. *Journey to the Stars: A History of Utah State University's Space Dynamics Laboratory*. Logan, UT: Utah State University Research Foundation, 2015.

⁹Lemon, 97-105, 139-141; Doran J. Baker, A.T. Stair Jr, Bartell C. Jensen, and M.K. Jeppesen, "Making History: The Ramos Program," *Quest: The History of Spaceflight Quarterly* 21, no. 3 (2014): 47-50.

The 2014 Olympic Winter Games as a Catalyst for Physical Activity

James Bemel

Utah Valley University

ABSTRACT

The bid for the London 2012 Olympic Summer Games included statements related to the potential impact of the Games on physical activity levels of United Kingdom residents. Additional studies suggest possible impacts on residents of non-host countries as well. The literature is not conclusive regarding this potential impact. HealthyPeople 2020 includes goals and objectives related to increasing physical activity among Americans and therefore, if the Games could potentially increase physical activity, this effect must be better understood. The purposes of this study are to (1) determine if the Sochi 2014 Olympic Winter Games resulted in a significant increase in physical activity among university students in Utah, (2) determine whether participants' physical activity stage of change was altered after viewing the Olympic Games, (3) determine if factors other than watching the Olympic Winter Games influence increases in physical activity, and (4) provide participants a mode of sharing their ideas and methods of utilizing the Games to increase physical activity. Participants were randomly selected and completed pre- and post-Games surveys inquiring about levels of physical activity, Olympic Games viewing behaviors, perceived and actual effects of viewing the

Olympic Games, and methods of utilizing the Games to promote physical activity. A total of 395 students completed the pre- and post-Games surveys. One area of physical activity (muscle-strengthening activities) significantly increased between the pre- and post-Games surveys. Twenty percent of those who reported increased physical activity levels indicated the increase was due to no reason other than watching the Olympic Games. No significant differences were found in participants' pre- and post-Games stages of change. While results indicate a limited potential for the Olympic Winter Games to increase physical activity, participants' suggestions for utilizing the Games to promote physical activity may be employed to positively impact Americans' exercise habits during and following the Olympic Games.

INTRODUCTION

During the bid for the London 2012 Olympic Summer Games, the authors of the bid included chapters on the improvement of healthy living and health inequities. They described a potential “demonstration effect” upon the population and theorized that a lack of public health vision in previous Games led to a missed opportunity and presence of outcomes detrimental to the public’s health (Wellings et al. 2011). According to Tessa Jowell, Culture Secretary and Olympics Minister, “Our Olympic bid...will be central to our efforts to increase physical activity. We want the Olympics to be the catalyst that inspires people of all ages and all talents to lead more active lives” (Department for Culture Media and Sport, 2007).

According to SportScotland (2004), following a gold medal win by the Scottish women’s curling team at the 2002 Olympic Winter Games in Salt Lake City, Utah, Scotland experienced an increased interest and participation in curling. Curling club membership increased by 3% after the Olympic win, and 38% of people new to curling between 2002 and 2003 indicated television coverage of curling was an important factor in their decision to take up curling. According to the authors, 36% of new curlers reported being influenced by the Scottish gold medal win.

Truño (1995) evaluated the potential psychological and behavioral effects after the 1992 Olympic Summer Games in Barcelona. The study found a psychological improvement in the Barcelonian population, including an improvement in citizens’ attitudes regarding physical activity and sports. The study indicated that the Olympics resulted in a significant increase in active sport participation within the population (36% in 1983, 47% in 1989, and 51% in 1995).

Despite the United Kingdom's support for promoting physical activity during the London 2012 Olympic Summer Games, other researchers found results refuting this effect. Sanchis-Gomar et al. (2012) hypothesized that the economic downturn may have impacted the ability of the London 2012 Olympic Summer Games to stimulate physical activity since participants usually must purchase the correct sportswear, gym membership, etc.

Prest and Partridge (2010) reported a limited link between sporting events and behavior change, with positive effects seen with the Tour de France, FIFA World Cup and British success at previous Olympic Games. O'Dowd (2012) acknowledged this limited effect but also recognized the potential opportunity to use the Games to inspire people in sports and physical activity.

Research by Coalter (2007) and Murphy and Bauman (2007) specified that while certain events may produce a post-event participation effect (e.g., increased sports club membership following the 1992 Barcelona Olympic Games, 1994 Soccer World Cup, and 2002 Winter Olympic Games), there is a lack of measurable impact on immediate post-Olympic Games participation. Weed et al. (2012) agreed with Coalter, indicating the greatest impact of a demonstration effect (when people are inspired by elite sport, sports people, and sports events to participate themselves) seems to be on those already active in sport and not on those who do not and have never played sports. Weed (2010) added to this by reporting that if an additional two million people are active following the Olympic Games, it would not be an indication the Games increased physical activity levels. Weed argued that seeking to use elite sport to inspire the least active people may have the opposite effect and may act as a deterrent because of a fear of not being good enough to participate (also known as the "competence gap").

Despite conflicting results of previous studies, the potential impact of Olympic Games to stimulate physical activity is still an important theory to pursue. This is especially true since any increase in physical activity will assist in accomplishing the HealthyPeople 2020 (United States Department of Health and Human Services 2010) goals related to physical activity (Table 1).

The following research questions were based on the literature review and guided this study:

Did the Sochi 2014 Olympic Winter Games significantly influence participant physical activity (i.e., aerobic and muscle-strengthening) levels?

Table 1. HealthyPeople 2020 Physical Activity Goals

| |
|--|
| PA-1: Reduce the proportion of adults who engage in no leisure-time physical activity (PA) |
| PA-2: Increase the proportion of adults who meet current Federal PA guidelines for aerobic PA and for muscle-strengthening activity |
| PA-2.1: Increase the proportion of adults who engage in aerobic PA of at least moderate intensity for at least 150 minutes/week, or 75 minutes/week of vigorous intensity, or an equivalent combination |
| PA-2.2: Increase the proportion of adults who engage in aerobic PA of at least moderate intensity for at least 300 minutes/week, or 150 minutes/week of vigorous intensity, or an equivalent combination |
| PA-2.3: Increase the proportion of adults who perform muscle-strengthening activities on 2 or more days of the week |
| PA-2.4: Increase the proportion of adults who meet the objectives for aerobic PA and for muscle-strengthening activity |

Did participant transtheoretical stages of change significantly shift after viewing the Olympic Games?

Were there additional reasons for participant increase in physical activity following the Olympic Games?

Is there a significant difference between participant perception regarding the influence of the Olympic Games on physical activity and the reality of this influence?

METHODS

Sample

The study utilized a random sample of students at Utah Valley University. Student status was the only inclusion criterion. No additional eligibility criteria were included. Randomly selected students received several email messages asking them to complete two internet-based surveys and offering to enter them into a drawing for a \$40 gift card. Data collection spanned a two-week period. The study was approved by the Utah Valley University IRB (approval #01166).

Instrument

Participants were asked to complete two internet-based surveys. The first (Pre-Games Assessment) was completed prior to the 2012 Olympic Winter Games and inquired about participants' current physical activity habits. The second (Post-Games Assessment) was completed 30 days after the conclusion of the Games and inquired about physical activity levels during the 30 days after the Games. With the exception of the demographic questions asked in the first survey, questions were mirrored on both surveys to allow for comparison. Questions were based on studies by Coalter (2007), Murphy and Bauman (2007), Weed et al. (2012), and HealthyPeople 2020 (United States Department of Health and Human Services 2010).

Participants spent an average of 15 minutes completing each survey and were asked questions on the following topics:

- Average weekly minutes spent engaging in moderate-intensity aerobic activity
- Average weekly minutes spent engaging in vigorous-intensity aerobic activity
- Average weekly days spent engaging in muscle-strengthening activity
- Lifetime activity level
- Current physical activity level stage as described by the Transtheoretical Model (Glanz et al. 2002)
- Height and weight
- Demographics

Quantitative results were calculated using SPSS 19.0 software and consisted of Chi-square, Spearman, Pearson, Wilcoxon, and Kruskal-Wallis tests of significance. All quantitative analyses utilized an alpha level of 0.05. Qualitative results were evaluated by the researcher to determine any relationships between responses and emerging themes.

RESULTS

A total of 395 surveys were completed. The average age of the respondents was 25.4 years with a range of 18 to 58 years. Fifty-two percent were female and 47% were male, with 1% not responding to the question. Additional demographics (e.g., race, ethnicity, class standing, course load, and area of study) are presented in Table 2.

| Table 2. Participant Demographics | |
|---|------------|
| Characteristics | n (%) |
| Race | |
| Caucasian or White | 348 (88.1) |
| Asian or Pacific Islander | 15 (3.8) |
| Multiracial | 14 (3.5) |
| American Indian/Native Alaskan | 8 (2.0) |
| African American/Black American | 2 (0.5) |
| Did not respond | 8 (2.1) |
| Ethnicity | |
| Hispanic | 33 (8.4) |
| Non-Hispanic | 355 (89.9) |
| Did not respond | 7 (1.7) |
| Class Standing | |
| Freshman | 76 (19.2) |
| Sophomore | 86 (21.8) |
| Junior | 109 (27.6) |
| Senior | 115 (29.1) |
| Graduate | 5 (1.3) |
| Not degree-seeking | 4 (1.0) |
| Course Load | |
| Full-time | 303 (76.7) |
| Part-time | 92 (23.3) |
| Area of Study | |
| College of Science of Health | 100 (25.6) |
| College of Humanities and Social Sciences | 79 (20.2) |
| School of Business | 65 (16.6) |
| College of Technology and Computing | 49 (12.5) |
| College of Aviation and Public Services | 29 (7.4) |
| School of Education | 24 (6.1) |
| University College (ESL, Pre-Health) | 14 (3.6) |
| School of the Arts | 13 (3.3) |
| Undecided/Undeclared | 17 (4.3) |
| Multiple majors | 1 (0.3) |

Descriptive Results

Out of 395 participants responding to the survey, 61% self-reported varying levels of lifetime sports and/or leisure time physical activity. Thirty-five percent reported high levels and 4% reported no sports or leisure time physical activity. Seventy-seven percent of respondents reported watching some portion of the Olympic Games.

Participants were asked about their specific Olympic Games event viewing with questions such as “Did you watch any portion of the curling events?” Results indicated the skiing and skating events were most popular (68.6% and 68.1%, respectively). Fifty-four percent viewed the bobsledding/skeleton events, 43% watched the hockey events, and 37% watched some portion of the luge events. The biathlon and curling events were least popular with 23% and 22% watching, respectively.

When participants were asked about their beliefs regarding whether or not the Olympic Games *encourage* physical activity, 72% answered affirmatively while only 48% believed the Games were actually *successful* at increasing physical activity. Ninety percent of respondents believed the Games *could be* utilized to encourage increased levels of physical activity. A discussion of the respondents’ suggestions for doing so is included in the “Qualitative Analysis” section.

Quantitative Analysis

Research question #1 inquired about whether the Sochi 2014 Olympic Winter Games significantly influenced the physical activity (i.e., aerobic and muscle-strengthening) levels of university students in Utah. Forty-three percent of respondents who viewed some portion of the Games self-reported an increase in personal physical activity level, although not all of the analyses support this information. Data analysis related to this question is presented in Table 3.

| Type of Activity | Pre-Games | Post-Games | Difference |
|--|-----------|------------|------------|
| Moderate-intensity aerobic activity (min/week) | 221 | 212 | -9.0 |
| Vigorous-intensity aerobic activity (min/week) | 120 | 125 | 5.0 |
| Muscle-strengthening activity (days/week) | 2.0 | 2.2 | 0.2* |
| Body mass index | 26.0 | 26.1 | 0.1 |

* Significant at a 0.05 alpha level

Three of the analyses indicated no significant differences between pre- and post-Games assessment. Two of those four analyses resulted in a change in the opposite direction hypothesized. The average number of

minutes respondents engaged in moderate-intensity aerobic activity decreased and the average body mass index (BMI) increased between the assessments. Although the average amount of vigorous-intensity aerobic activity increased, the increase was not significant at an alpha level of 0.05. Despite these findings, a significant increase was present between the pre- and post-Games assessments regarding days engaged in muscle-strengthening activities ($t=-2.094$, $p=.037$). Respondents increased the average amount of muscle-strengthening activity by 0.2 days per week.

Respondents who self-reported an increase in physical activity were asked "To what extent did your watching of the Olympic Winter Games impact your increase in physical activity?" Potential responses ranged from 0 (not at all) to 10 (a great extent). Results are presented in Figure 1.

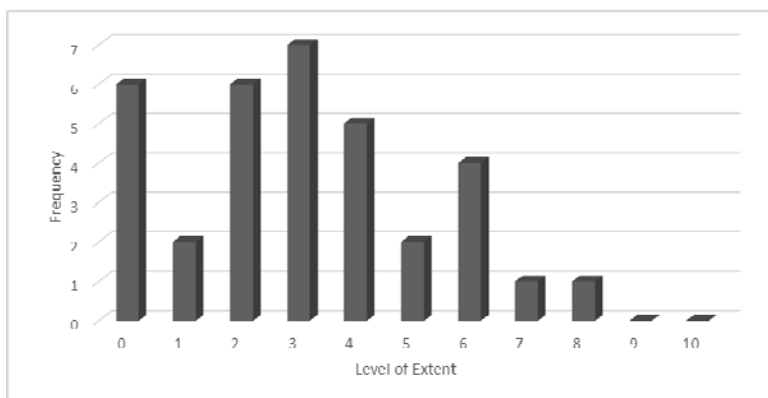


Figure 1. Extent to which viewing the Olympic Games resulted in increased physical activity

Seventy-seven percent of respondents specified a level less than five, indicating a low level of influence of the Olympic Games on increases in their physical activity.

Research question #2 inquired about participants' pre- and post-Games level of physical activity as described by the Transtheoretical Model (Glanz et al. 2002). Results are presented in Table 4.

Pre- and post-Games data indicate a decrease in precontemplation and an increase in preparation and action, suggesting an increase in awareness of and preparation for increased physical activity among the respondents. These differences were not significant at the 0.05 level.

| Table 4. Transtheoretical Stage of Change Regarding Physical Activity | | |
|--|------------------------|-------------------------|
| Stage of Change | Pre-Games n (%) | Post-Games n (%) |
| Precontemplation | 44 (11.1) | 42 (10.6) |
| Contemplation | 149 (37.7) | 134 (33.9) |
| Preparation | 65 (16.5) | 71 (18.0) |
| Action | 69 (17.5) | 88 (22.3) |
| Maintenance | 68 (17.2) | 60 (15.2) |

Note: no significant differences at an alpha level of 0.05

Research question #3 examined any additional reasons for participants' increase in physical activity following the Olympic Games. Twenty percent of respondents who reported increased levels of physical activity after the Games indicated no reason for this increase other than watching the Games. Qualitative results related to the additional reasons for increased physical activity are presented in the "Qualitative Analysis" section.

Research question #4 inquired about whether a significant difference existed between participants' *perception* regarding the influence of the Olympic Games on physical activity and the *reality* of this influence. Data analysis revealed a significant relationship between participants' beliefs about whether the Games encourage an increase in physical activity and the participants' actual self-reported extent to which the Games increased their activity level ($r=.511$, $p=.002$). Twenty percent of those who reported an increase in physical activity indicated no reason other than watching the Games.

Qualitative Analysis

Research question #3 inquired about additional reasons for participants' increase in physical activity after the Olympic Games, and 20% of those who reported increased levels of physical activity indicated no reason other than watching the Games. Table 5 includes the emerging themes from the 80% who indicated another reason for their increased physical activity.

As reported in the "Descriptive Results" section, 90% of respondents believed the Games *could be* utilized to encourage increased levels of physical activity and a total of 174 responses/recommendations were collected. Qualitative analysis resulted in the themes presented in Table 6.

| Table 5. Factors Influencing Increases in Physical Activity | |
|---|-----------------------|
| Theme | Proportion (%) |
| Warmer weather/Change in seasons | 27.3 |
| General personal motivation (e.g., felt out of shape, noticed weight gain, clothes fit tightly) | 19.7 |
| Training for upcoming event (e.g., marathon, biathlon, triathlon, Ragnar, sports, competition) | 17.4 |
| Exercising w/friends or family | 10.6 |
| New gym pass, exercise equipment, health challenge participation, etc. | 5.3 |
| Upcoming vacation | 5.3 |
| Current enrollment in a health/fitness class | 3.8 |
| Healed from previous injury/illness | 3.0 |
| Swimsuit season approaching | 2.3 |
| To assist healing of current injury/illness | 1.5 |
| Employment is physically demanding | 1.5 |
| Mandatory fitness testing (e.g., military) | 0.8 |
| Media (e.g., Bigger, Faster, Stronger) | 0.8 |
| Forced to exercise (e.g., car was wrecked and had to walk or ride a bike) | 0.8 |

| Table 6. How the Olympic Games Could Be Utilized to Encourage Physical Activity | |
|--|-----------------------|
| Theme | Proportion (%) |
| More (or better) advertising/marketing regarding health improvement | 35.1 |
| Highlight athletes' training/exercise habits | 30.5 |
| More opportunity for public interaction/engagement with the Games | 22.4 |
| Remove commercials promoting unhealthy eating/exercise habits | 2.9 |
| Television viewing habits | 2.3 |
| Politics/logistics | 1.7 |
| Miscellaneous/other | 1.7 |
| Exposure to the Games through media other than TV | 1.1 |
| Demographic differences | 1.1 |
| More focus on the events rather than the athletes | 1.1 |

Seven common themes emerged during the analysis process. The largest proportion of comments (35.1%) were related to an increase or

improvement of advertising/marketing related to improving health. The following are examples of comments from respondents:

Advertisements promoting sports and exercise in general not just Olympic sports

Ads with athletes telling why they started (targeted toward children)

Maybe have athletes do commercials that show how to incorporate working out into a daily routine for an average individual

The athletes could do service announcements between Games that suggest basic/fun ways people can start trying to get more physical activity while enjoying themselves.

The next largest proportion of comments (30.5%) related to highlighting athletes' training/exercise habits. Comments included:

Encouraging me to become like the athletes competing. If they were to show step-by-step exercise routines that the athletes used, I do believe that would push me to do those same routines and in turn increase my personal levels of physical activity.

I would like to see more about their personal workouts and what they did nutrition-wise and for strength training.

Show some of the simpler activities Olympians do to prepare their bodies physically, things that people would be able to do weekly.

Highlighting stories of athletes (Olympic or otherwise) that have struggled with weight or motivation

They could talk more about how athletes train, specifically showing their lifestyle including diet and exercise programs. This would take the perspective from someone who is really talented to someone who is talented but also worked hard to get to the Olympics. Then people start thinking about what they could accomplish if they did similar lifestyle changes.

The third most popular theme (22.4%) considered increasing the amount of public interaction/engagement with the Games. Comments included:

I remember when I was younger and the Olympics were on my family held mini Olympics and we had our own competitions. It was more for fun, but it got us doing something.

Have places like gyms and places that you can do Olympic activities do promotions during the Olympics.

I think if local ski resorts and skating venues had mock Olympic events that were free or low price there would be an increase in physical activity.

Some sort of mobile app release from the Olympic committee that makes watching the Olympics and working out an interactive experience. Comparing workout routines with Olympic courses and stats.

I think it could have been more effective for me if on the Olympic website (or if it were to be advertised during the broadcasts) had information about where I could go or how I could start to learn a new winter sport. I think the Olympics sparks our interest, but don't show you how you could become more involved in winter sports yourselves. They should work with and advertise for different regions ways you could start a new sport, or at least find more information about it.

These three themes comprised 88% of the comments submitted. The remaining four themes comprised 12% of all comments and the proportion of these themes ranged from 1 to 3%. Several comments were made regarding the removal of unhealthy commercials/sponsors from the Games. Comments included:

Get rid of McDonald's commercials

Fewer fast food commercials sponsoring the Olympics. Kind of hard to want to improve your health when those McDonald's chicken nuggets are sponsored by athletes.

A lot of the athletes support fast food chains because they are paid to, that sends a mixed message.

Some respondents commented that watching television in-and-of-itself is an unhealthy behavior. Sample comments included:

Less TV coverage. I do not think sitting down to watch a sporting event will get someone to do physical activity

Any encouragement towards physical activity from the Olympics is counteracted by the fact that people sit down in front of the TV or computer to watch the games.

If you watch the whole thing there is no time to exercise...Olympic junkies don't go outside because they watch it all day long.

Three comments were made regarding the politics/logistics of the Games:

Not holding the games in controversial countries like Russia

Have every event available to watch, instead of whatever NBC wants to show

Better showing hours

The “Miscellaneous” theme included the following three comments that could not be categorized into any other theme:

Setting goals and working to accomplish them can be just as satisfying as a gold medal; no matter the level of competition.

I think it would make people feel lazy or inspired and they would then want to become more active.

I loved that the Olympic Games were played at the gym—it was motivation to run faster and lift more watching athletes do better. I think the Olympic Games should be broadcast on campus in the library and lounges to promote more well-being.

The following comments were recorded regarding exposure to the Games through media other than television:

More exposure to it. I am an extremely busy working college student. As such, I did not make time to sit down and watch a portion of the games. Nonetheless, I never even noticed that they were going on because there was little broadcasting or discussion of the Olympic Games in my "spree of existence." I forgot they were happening. If I saw or discussed them more, maybe I would have been motivated to try one of those sports.

Short YouTube ads showing amazing clips of Olympic Winter Games—I would have seen those.

The “demographic” comments included:

Because most of the athletes are younger than me it seems like the best way to utilize it for increased activity would be to focus on younger individuals to start similar activities. For those of us older than 30, letting us know that we're not dead yet and even though we may be past our prime a lot of the activities done in the Olympics can be enjoyed by a variety of ages.

Give something for younger generation folk to try for, and I don't know how you would encourage the older folk.

The following comments were made regarding more focus on the events rather than the athletes:

Side figures and charts and diagrams explaining the events

They could talk about the athletics and not the athletes or Russia

DISCUSSION

Conclusions

Conclusions from this study are mixed. Four areas of physical activity were measured, with the only significant increase in the area of muscle-strengthening activity. This indicates a potential relationship (supporting the findings of Truño 1995), but these findings do not support the theory of an increase in physical activity due to viewing the Olympic Games. This is reinforced by participants' self-reported extent to which watching the Olympic Winter Games resulted in increased physical activity (Figure 1). Most (77%) indicated a low level of Olympic Games influence. Data analysis indicated a moderate shift between pre- and post-Games stages of change, but none of the changes were significant. Viewing the Olympic Winter Games may not be significantly effective at moving people from one stage of change to another. These findings support the previous findings of Sanchis-Gomar et al. (2012), Prest and Partridge (2010), O'Dowd (2012), Coalter (2007), Murphy and Bauman (2007), Weed et al. (2012), and Weed (2010).

While quantitative results did not provide overwhelming support for an impact from the Olympic Games on physical activity, participants provided a variety of qualitative results when asked about additional reasons for their increase in physical activity following the Olympic Games. Eighty percent of respondents who indicated another reason for their increased physical activity provided qualitative responses classified into 14 different categories. It's important to note that 20% of respondents who reported an increase in physical activity indicated no reason for the increase other than viewing the Games. This indicates a potential effect of the Games upon individual physical activity levels.

When participants were asked about their perception regarding the influence of the Olympic Games upon physical activity and the reality of this influence, interesting results were found. While data analysis indicates 48% *believed* watching the games resulted in increased physical activity, only 8.5% of those who watched the games *actually* increased their levels of physical activity for no reason other than watching the Games. This indicates a discrepancy between participants' *perception* regarding the influence of the Games versus the *reality* of this effect.

Results do not provide a significant amount of evidence supporting the theory that viewing the Olympic Winter Games results in increased levels of physical activity. However, the qualitative data

regarding how the Games could be better utilized to do so may prove to be useful during future Olympic Games. Implementing suggestions listed in the Qualitative Data section might result in significant changes to physical activity levels following future Games.

Limitations

Two major limitations were encountered during the study process. While very few delimitations were implemented when selecting potential participants, the sample was selected from the current student body at Utah Valley University. This study can only be generalized to that population. Future research should utilize a random sample of the general population to provide more generalizable results.

The study is limited by the nature of qualitative research providing more variability compared with quantitative research. Since the researcher was responsible for interpreting participants' comments, the study is limited by the researcher's potential bias when reading the qualitative comments. Future research should include the use of a qualitative computer software program such as NVivo10 or ATLAS.ti.

Recommendations for Future Research

The Olympic Games occur every two years (alternating between the Summer and Winter Games). Researchers are afforded a unique opportunity to study viewers' habits prior to and following the Games. This structure allows researchers to identify weaknesses and strengths occurring during one set of Games, pass that information to coordinators of the next Games, and research the new effects. As mentioned in the Limitations section, future research on the physical activity effects of viewing the Olympic Games should include a more representative sample and the use of a formal qualitative research computer software program for more accurate data analysis.

Future research should focus on the Summer Games as well as the Winter Games. The Summer Games may be more effective at increasing physical activity compared with the Winter Games because the sports featured typically require significantly less clothing. Viewers are more exposed to the athlete's physical form during the Summer Games potentially leading to a motivation to become physically active.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of the students who completed the assessment.

REFERENCES

Coalter, F. (2007). London Olympics 2012: The catalyst that inspires people to lead more active lives? *The Journal of the Royal Society for the Promotion of Health*, 127(3), 109-10. doi:10.1177/1466424007077342.

Department for Culture Media and Sport. (2007). Tessa Jowell's London 2012 Olympics statement to the House of Commons. Retrieved July 15, 2011, from webarchive.nationalarchives.gov.uk.

Glanz, K., Rimer, B.K., & Lewis, F.M. (2002). *Health Behavior and Health Education: Theory, Research, and Practice*. San Francisco, CA: Jossey-Bass.

Murphy, N.M. and Bauman, A. (2007). Mass sporting and physical activity events: Are they “bread and circuses” or public health interventions to increase population levels of physical activity? *Journal of Physical Activity and Health*, 4, 193-202.

O'Dowd, A. (2012). London Olympics are unlikely to have beneficial public health legacy, peers hear. *British Medical Journal*, 344. doi:10.1136/bmj.e4202.

Prest, S. and Partridge, R. (2010). 2012 Olympics: A catalyst for behaviour change? *Perspectives in Public Health*, 130(6), 257-8.

Sanchis-Gomar, F., Martinez-Bello, V.E., Pareja-Galeano, H., & Lippi, G. (2012). The financial crisis implications on the expected 2012 Olympics public health effect. *Perspectives in Public Health*, 132(2), 59.

Sportscotland. (2004). *Curling Success and its Impact on Participation*. Edinburgh, Scotland: Caledonia House.

Truño, E. (1995). Barcelona: City of sport. Centre d'Estudis Olímpics UAB. Retrieved July 10, 2011, from http://olympicstudies.uab.es/pdf/wp039_eng.pdf.

United States Department of Health and Human Services. (2010). HealthyPeople 2020. Retrieved July 10, 2011, from www.healthypeople.gov.

Weed, M. (2010). How will we know if the London 2012 Olympics and Paralympics benefit health? *British Medical Journal*, 340, 1205-6. doi:10.1136/bmj.c2202.

Weed, M., Coren, E. Fiore, J., Wellard, I., Mansfield, L., Chatziefstathiou, D., and Dowse, S. (2012). Developing a physical activity legacy from the London 2012 Olympic and Paralympic Games: A policy-led systematic review. *Perspectives in Public Health*, 132(2).

Wellings, K., Datta, J., Wilkinson, P., & Petticrew, M. (2011). The 2012 Olympics: Assessing the public health effect. *The Lancet*, 378, 1193-1195. doi:10.1016/S0140-6736(11)60550-3

Attitudinal Shifts in Student Perceptions of Academic Service-Learning: An Exploratory Study of a General Education Humanities Course

Kimberli M. Lawson

Utah Valley University

Abstract

My purpose in employing a community-engaged project for the General Education Humanities course is to dispel what I consider to be a false, limiting belief that art remains largely unconnected to real life. To facilitate the exploration of the idea that we interact with, and react to, art frequently throughout our day-to-day experiences, I pose the following research question to students: "How can art transform a local community space?" The student teams research the needs of an assigned demographic, examine the uses of the facility they are assigned, and find out about how different kinds of art might fill different emotional, social, or intellectual needs. They also study articles and interviews that assert the transformative power of art. They then write a research-based proposal to the facility that synthesizes all of their findings and makes specific suggestions to the facility. They also present to a panel and prepare a conference poster. I

track quantifiable shifts in students' belief systems using 12 questions in six categories from the beginning of the semester to the end of their project through the collection of survey data. In 11 out of 12 categories, student perceptions of the benefits of the academic service-learning project to them became more positive.

The Importance of Research and Evaluation

A vital question surrounding academic service-learning is whether teachers are maximizing correct teaching strategies to create educational opportunities out of community service. Many important questions exist about how to execute a service-learning project in a way that justifies academic credit. Faculty and administrators differ in their opinions about whether, and to what extent, students should be working in government agencies, community non-profit aid organizations, or local businesses, for college credit—or in other words, in lieu of more traditional academic college course work. While there are certainly persuasive arguments on many sides of this debate, current trends in higher education are moving toward more engaged learning activities such as internships and service-learning. Because of this, faculty need to ask questions about how their teaching practices adapt to new environments and learning challenges presented in the realm of academic service-learning. Skeptics rightly inquire to what extent academic service-learning, although very popular with students, has a significant positive impact on what students learn. There is a need to evaluate the nature of learning that takes place within academic service-learning courses and to determine how this learning meets existing departmental and institutional goals and expectations. All pedagogical innovations should face the test of their own impact on core academic missions of higher education.

Student learning does not automatically happen without targeted and informed instructor intervention. For knowledge to transfer from one context to another, instructors must explicitly and repeatedly demand that students examine these connections within an academic framework. The process of reflection must be rigorous and repeated, and the role of the instructor is to keep the student from wandering off-task if intellectual gains are a desired outcome. Instructors must push students well beyond the easy response of “it feels good to help people.” Further, academic service-learning executed properly needs to align with the learning outcomes of the class. One potential pitfall of service-learning is that it may not adequately connect the service to the learning if the work performed by the students does not correlate with

learning goals and course objectives. When constructed correctly by the instructor, academic service-learning projects should serve both the communities and the students who execute the project, but this does not simply happen automatically.

Academic service-learning is distinct from volunteerism. Volunteering is more in line with performing charitable acts such as working in a soup kitchen or collecting used coats for a homeless shelter. While these acts are valuable, they work within a model of one-way giving—the volunteer performs an act that benefits a needy person. Academic service-learning, in contrast, indicates a two-way benefit that is less paternalistic and more reciprocal. The hyphen in the phrase “service-learning” indicates a continued balance between service to the wider, nonacademic community and the academic learning central to college education. Under the best conditions, students should gain new skills, new knowledge and information, and new experiences that enhance their education as a whole.

Introduction: Course Context and Student Projects

The Humanities as a field did not initially embrace academic service-learning with the same gusto as many other academic fields at the university level (Yeo 160). Scholarly research on academic service-learning throughout the 1990s revealed that “while both research related to service-learning and the practice of service-learning were on the rise in a number of higher education fields during this period, there were indications that it was much less firmly rooted within many of the humanities disciplines” (Baca and Owens 4). Other academic majors, such as education, social work, and business, embraced the field of service-learning much earlier, and with more enthusiasm. Even in the late 1990s, studies continued to suggest that fields inside Humanities were seen as “inherently less compatible with service-learning initiatives than were disciplines which were likely to be viewed as more practical in their orientation and application” (Baca and Owens 4). Despite this initial lag, faculty in departments of Humanities over the past 10 to 15 years have begun to incorporate academic service-learning into their courses in larger numbers, suggesting that there is not necessarily an inherent incompatibility between the study of various art forms and service-learning curricula, although, in truth, connections may not be as immediately obvious in a Humanities course as in other majors such as social work, psychology, or nursing.

At Utah Valley University, students in our General Education Humanities course sometimes believe that the introduction to fine arts is a waste of their time and that it has no real-life relevance for them.

Because of this student resistance to the subject matter, I began to explore the topic of academic service-learning as a possible means of presenting subject matter within a real-world project. My purpose in employing an academic service-learning project for this course is to dispel what I consider to be a false and limiting belief held by some students that art, in all its forms, remains unconnected to real life. To facilitate the exploration of the idea that we interact with, and react to, art frequently throughout our day-to-day experiences, I posed the following research question to students: “How can art transform a local community space?” This question guided the community engaged project that I constructed for students to complete in teams, as I asked them to consider how the fine arts can interact with a real-world space in a targeted way to create an effect or experience for people in that space.

Teams were all assigned to research and serve at the Food and Care Coalition, a local community organization that provides meals to low-income and homeless people and also offers some transitional housing facilities for adults and other services. The student teams researched the needs of this demographic in more detail, examined the uses of the facility, and found out about how different kinds of art might fill different emotional, social, or intellectual needs. They also studied articles and interviews that asserted the transformative power of art in its social, emotional, and intellectual effect on people who encounter it. They then wrote a research-based proposal to the facility that synthesized all of their findings and made specific suggestions about which art and artistic activities they believed would be most beneficial for this local environment and the clientele being served by the Food and Care Coalition. This assignment was designed to be both research based and creative.

I created an additional layer of professionalization by requiring not only a written proposal for the community partner (a real-world deliverable), but also a conference poster similar to what graduate students, or even advanced undergraduates, along with career researchers and academics, might be required to produce. Further, I required the teams to present an oral executive summary to a real-world panel of their course instructor, the community partner, a fine arts academic, and a local business leader. These project requirements were designed to help the students develop professional skills such as consulting, data collection and analysis, report preparation, and oral presentation.

We were very fortunate to have a community partner that was already deeply engaged in the spirit of the project. The director of the Food and Care Coalition, who has been with the service-learning

project since the concept phase, is extremely committed to the integration of art into the space. The facility itself is a spacious and welcoming building that is quite lovely on the outside as well as the inside. It consciously integrates both art and interior design to create a sense of beauty in the common areas of the main floor. Sculptures welcome the visitor at the main entrance and in the enclosed back areas of the facility, and the grounds are attractively landscaped. Most of the students were astonished by how nice the facility is. I heard well over a dozen comments about how students thought that the facility would be a warehouse, would be run-down, or would be cobbled together with a minimum of cost and effort.

The director of the Food and Care Coalition, during each of his four tours offered to the students, explained that his primary goal in creating this facility was to transmit the message to the clients that “you are a person of worth.” This message of inherent value even caused a small amount of push-back during initial tours of the facility at its grand opening because a few people wondered at the wisdom of spending quite so much on “beautification.” This presented a new perspective for the students to consider, that all citizens should be exposed to paintings and sculpture. This was incredibly valuable for me as a teacher to have the community partner stress a point that is at the core of my introductory course: that art has a vibrant and vital place at the heart of human spaces.

My Research Project: General Findings

My exploratory research questions for this study centered on how the students perceived the course benefitting them. Through survey questions administered both before the academic service-learning project began and after students concluded their project, I tracked quantifiable shifts in students’ belief systems using 12 questions in six categories collected through surveys. The six survey categories that I attempted to track are: 1) Create links between service-learning and professional career; 2) Enhance course learning; 3) Perceive real-world applications for studying the fine arts; 4) Develop empathy and social responsibility; 5) Create or enhance a desire to serve one’s community; and 6) Believe that community service is good/desirable. Within each of these categories, I had two survey questions that asserted a position on the topic (Table 1). I then asked the students to score their personal opinion about the position on a 7-point scale from “strongly agree” to “strongly disagree” with the intent to track shifts in student perceptions and beliefs in an academic service-learning course from before their project started to after the completion of their project. Student

responses after the completion of the academic service-learning project went up in 11 out of 12 survey questions, indicating that students perceived positive outcomes from the project, with only the responses to Question One, “This service-learning project offers valuable experience for my resume,” falling in the post-project survey. For this survey question, the top score of “strongly agree” dropped 3%, from 32% before the project to 29% after the project. The combined “agreement” categories of “somewhat agree,” “agree,” and “strongly agree” when added together also fell from 93% to 82%.

Table 1. Survey Questions

| |
|---|
| <p>Topic: Create links between service-learning and professional career</p> <ol style="list-style-type: none"> 1. This service-learning project offers valuable experience for my resume. 2. This service-learning project helps me develop new skills that will transfer to a job. |
| <p>Topic: Enhance course learning</p> <ol style="list-style-type: none"> 3. This service-learning project helps me to apply the theoretical course content to a real-world project. 4. I feel like I retain knowledge from the class better because of the service-learning project. |
| <p>Topic: Perceive real-world applications for studying the fine arts</p> <ol style="list-style-type: none"> 5. I believe that exposure to the fine arts is valuable for all members of my community. 6. Knowledge about the fine arts can help me solve real-world problems more effectively. |
| <p>Topic: Develop empathy and social responsibility</p> <ol style="list-style-type: none"> 7. This service-learning project allows me to serve people in my community who need help. 8. I feel sympathy and connection towards the homeless and very poor because of this project. |
| <p>Topic: Create or enhance a desire to serve one's community</p> <ol style="list-style-type: none"> 9. It is important to me to have a sense of contribution and helpfulness through participating in community service. 10. I am confident that I will participate in community service activities in the future. |
| <p>Topic: Believe that community service is a good/desirable thing</p> <ol style="list-style-type: none"> 11. Providing volunteer service to my community helps improve the local community. 12. Improving communities is important to maintaining a quality society. |

My Research Project: Some Specific Findings

I will not examine all the data in-depth here, but will look closely at two survey question results and related written comments. For me, the survey data became more interesting in the instances that I was able to pair it with written reflection from students that seemed to offer some illumination or explanation for shifts in student beliefs. I assigned several reflection essays to assist students in their learning and analysis, since reflection essays are widely considered a best practice and a powerful process variable within academic service-learning courses.

The biggest jump upward of the survey occurred on Question 8: “I feel sympathy and connection towards the homeless and very poor because of this project.” The top score of “strongly agree” rose 23%, from 18% before the project to 41% after the project (Figure 1). The combined “agreement” categories of “somewhat agree,” “agree,” and “strongly agree” when added together also rose from 70% to 85%. This is considered an important change by many researchers of academic service-learning because it hints at reductions in negative stereotypes and at increased tolerance of groups different from the students’ own. This type of learning is often categorized by researchers as personal development. A holistic view of learning would argue that “personal and interpersonal development” are linked to “academic and cognitive

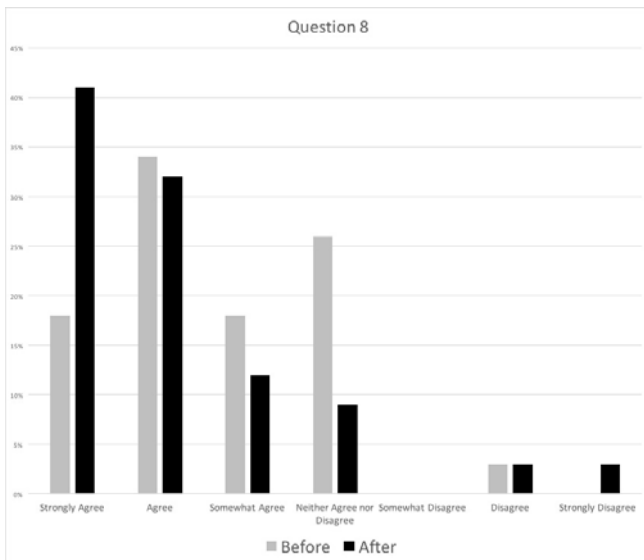


Figure 1. Changes in students’ responses pre- and post-project to Question 8: I feel sympathy/connection toward the homeless and very poor

development,” and that much learning involves “values as well as ideas. One goal of academic service-learning is to connect the multiple dimensions of human development that are often separated on college and university campuses” (Eyler and Giles 7-8).

Reduction in stereotypes and increased tolerance are, in fact, listed as course outcomes on many syllabi, so this experiential approach to teaching these concepts seems particularly effective. Student reflection essays concerning pre-existing beliefs about the homeless as well as student shifts in attitude were very revealing. One student wrote that “in the process of doing this [research], I gained a new perspective. It was astounding to me to learn how these different people ended up being homeless or needing help in other ways. Before, I felt like if you were homeless it was because you didn’t have a work ethic and just wanted to be given a handout. Now, after doing research, I know that this isn’t always the case.” This student was able to see real-world applications for the research that he did and was also able to synthesize that information into an adapted world view. This outcome is both impressive and desirable. Another student provided an example of increased empathy with a group very different from his own when he remarked that “sometimes even great people with lots of intelligence lose themselves to diseases and become homeless. I thought, ‘what if this happens to me?’” This student was able to broaden his perspective by empathizing with a position that he had not held before.

Question Two on the survey (“This service-learning project helps me develop new skills that will transfer to a job”) also yielded interesting results. The top score of “strongly agree” rose 16%, from 22% from before the project to 38% after the project (Figure 2). The combined “agreement” categories of “somewhat agree,” “agree,” and “strongly agree” stayed absolutely still at 85% for both surveys, although the strength of the agreement shifted up as a result of the student project. These student opinions can be understood better by looking at reflection essays on this topic, in which students offered a wide array of evidence for this shift in belief, sometimes connecting their arguments back to their specific majors.

Some students remarked that crossing boundaries between academic work and professional interactions was a new experience for them. One woman stated that “the project that we performed at the Food and Care Coalition was an interesting experience that I have never had before in my schooling. I never have felt an influence from my school work affect the outside world.” Although academic service-learning is a growing trend in universities, only a small minority of my students had any previous experience with this type of learning. Another student itemized the skills he felt that he had exercised during the project:

“Some of the tools that I felt like we had to use during these projects were problem solving, working with a group, being involved with an actual problem and forming a solution to the problem, and developing creative skills. I also think doing these service learning projects enhances your ability to network and see different businesses and how they operate.” Problem solving and thinking creatively are course outcomes for a large number of courses across the curriculum, and the student’s awareness of his own implementation of these skills is valuable both to the student and the instructor.

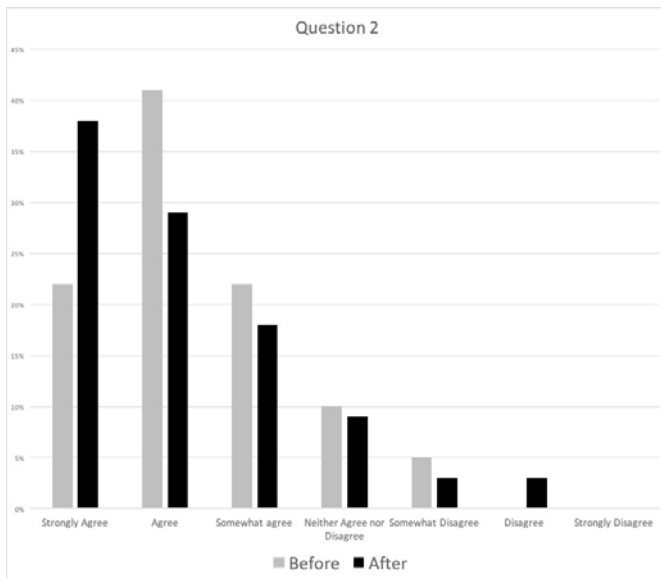


Figure 2. Changes in students’ responses pre- and post-project to Question 2: Learning skills that will transfer to a job

A third student made connections directly to her major and to her future career. She stated, “I intend to be a writer or editor after graduating. This project helped me gather real life experience in what it would take to research a topic for an article. Writing a paper for an audience such as my group members, my teacher, and for the board made me take the writing more seriously. It made me double and triple check the information I gathered. It also made me edit my writings more heavily than I would for other essays I have done in college.” This student’s choices illustrate a greater commitment and care shown toward her work because she believed that it mattered in the real world

to the Food and Care Coalition and that other people would be seeing it, evaluating it, and making decisions based on it.

The most mentioned professional benefit was the opportunity to work in a team. Many U.S. colleges and universities openly acknowledge this gap in training for civic and professional life. Former president of Indiana University Thomas Ehrlich noted that “the most frequent criticism...from both community leaders and employers, was that our graduates were unprepared to collaborate as members of a team. While most of the tasks that they would be called on to perform in their communities and workplaces would be as team members, most of their undergraduate work had been done alone” (Ehrlich qtd. in Eyler and Giles 23). Criticism like this is especially useful for departments like my own, the Humanities, which are from time to time challenged based on the practicality of the major vis-à-vis post-graduation employment. While we claim, in response, that we teach critical thinking, writing, and communication skills, it may also be beneficial to enhance our focus on collaboration and team work.

Next Steps and Initial Conclusions

Research on academic service-learning continues to be of interest to many groups of people, including faculty, college deans, university presidents, directors of campus service programs, students, and community agencies. Because I believe that faculty should continually interrogate their own teaching practices, the next step in my research process will be to create and execute an explanatory study, attempting to understand and discover *why* student perceptions shift, and how what I do, as the teacher, influences this in terms of how I set up the academic service-learning project parameters. I believe that the local community space is not the only thing that can be potentially transformed through this engaged learning project. My students were also transformed in three categories. First, their belief in the power of art to shape a physical space was transformed. Second, their belief in their ability to make a difference in their own community was enhanced. Third, their understanding of how to organize and execute a meaningful project was expanded.

Bibliography

Baca, Isabel and Joana Owens. “Editors’ Introduction: Opening the Doors to Service-Learning in the Humanities.” *Interdisciplinary Humanities* 29.3 (2012): 3-7. Print.

Eyler, Janet and Dwight E. Giles, Jr. *Where's the Learning in Service Learning?* San Francisco: Jossey-Bass, 1999. Print.

Yeo, Michael. "An Agenda for Service-Learning in the Humanities." *Interdisciplinary Humanities* 29.3 (2012): 159-176. Print.

Collaboration and Performance in the Pessoa/Queiroz Love Letters

Todd Kimball Mack

Southern Utah University

Abstract

Fernando Pessoa's heteronymic project is surely one of the most important literary acts of the 20th century and perhaps in all of history. Although it is common to think of Pessoa as a tormented and solitary genius, this article examines questions of collaboration and performance in the love letters exchanged between Pessoa and Ofélia Queiroz. For decades, criticism regarding this correspondence focused almost exclusively on Pessoa's psychological state and on the heteronymic games he played with (or jokes he played on) Queiroz. In this article, based on theories of play, performance, and collaboration, I show Queiroz's willingness and ability as a collaborator in the Pessoaan artistic creation from the beginning of the relationship in 1921—when Pessoa confesses his love to her in an improvised and spontaneous scene from Hamlet—until the end of their relationship in 1931.

Pouco antes de ele morrer, o meu sobrinho Carlos encontrou-o [Pessoa] no Martinho da Arcada e ele perguntou-lhe: 'Como está a Ofélia?' Apertou-lhe as mãos com muita força e

com os olhos marejados de lágrimas disse-lhe: 'Bela alma! Bela alma!' (Queiroz, "O Fernando e eu" 44)¹

Introduction

In this article, I will discuss the importance of collaboration and performance in the amorous relationship between Fernando Pessoa and Ofélia Queiroz as depicted in Queiroz's description of the events, entitled "O Fernando e eu" ["Fernando and me"], and the actual love letters written between the two. In my analysis, I will highlight the creative give-and-take of the relationship, and I will show that Ofélia proved a willing and active partner with Pessoa in their creative games. To do this, I will first discuss the secondary criticism dealing with Fernando and Ofélia's relationship, pointing out how it fails to take into account the collaborative creativity of the lovers—especially on the part of Ofélia. I will then introduce a theoretical framework—based on theories of performance, play, and collaborative communication—that allows for a more comprehensive understanding of the relationship by highlighting the importance of their shared theories of interpretation. I will finish with a close reading of two important and well-known episodes in the relationship—namely the performance of *Hamlet* described by Ofélia in which Fernando first pronounces his love to her, and an infamous letter addressed to Ofélia by one of Pessoa's heteronyms, Álvaro de Campos. In the conclusion, I will briefly discuss the eventual end of the relationship. Each of these episodes highlights the way in which throughout their relationship Ofélia and Fernando performed together in a playful way—each one reacting to the cues given by the other to create meaning through sharing and collaboration.

History of Analysis

Early analysis of the Pessoa/Queiroz relationship was hindered for years by lack of access to important documents. João Gaspar Simões first explored the lovers' relationship in *Vida e obra de Fernando Pessoa* [*Life and Work of Fernando Pessoa*] (1951). Simões had no access to any of the lovers' correspondence, nor had he any knowledge of Ofélia's point of view, which surely contributed to his describing

¹ "Shortly before dying, my nephew Carlos met [Pessoa] in Martinho da Arcada and he asked him: 'How is Ofélia? He held his hands with great force and with his eyes filled with tears he told him: 'Beautiful soul! Beautiful soul!''" [All footnoted translations are my own.]

Fernando in the following simplistic Freudian terms: “Criança—adolescente, melhor—, esperava da amizade, do amor maternal ou feminino o que não podia esperar nem da arte, nem da vida, nem de si próprio” (476).² This phrase stood as the most important analysis of the Pessoa/Queiroz relationship until Fernando’s love letters were published in 1978. But even that archive is limited by the absence of Ofélia’s voice. In an explanatory essay, the collection’s editor states: “As cartas existem; e são as únicas ‘cartas de amor’ que de Fernando Pessoa se conhecem; e ei-las agora integralmente publicadas pela primeira vez. Estes, os factos. Só estes” (Mourão-Ferreira 188).³ In 1978, this statement was unfortunately true. There was only one set of letters, and they constituted the facts of the relationship.

The next major intervention in the Pessoa/Queiroz analysis was the biography by Robert Bréchon: *Etrange étranger* [*Strange Foreigner*] (1996). Published the same year as Ofélia’s love letters, his argument accounts for her version of the events (“O Fernando e eu”—published along with Fernando’s letters), but not her letters. Bréchon states that despite the playful tone of some of Fernando’s letters, there is still in them “un contenu sérieux. Il y a même, dans toute cette correspondance, malgré le ton faussement enjoué, quelque chose de tragique” (357).⁴ He continues: “Ce ton infantile n’est pas innocent. Tous les commentateurs, à commencer par l’éditeur des Lettres, David Mourão-Ferreira, ont bien senti que le ‘ridicule’ dénoncé plus tard par Alvaro de Campos, et le tragique, que le lecteur perçoit entre les lignes, ont l’un et l’autre quelque chose à voir avec l’enfance” (357).⁵ Bréchon recognizes that there is something youthful in Pessoa’s letters, but he remains unconvinced of this explanation: “Les Lettres d’amour s’expliquent par les souvenirs d’enfance et elles éclairent cette enfance.

² “A boy—an adolescent, rather—, he expected from friendship, from maternal or feminine love that which he could not hope to find in art, nor in life, nor in himself.”

³ “The letters exist; and they are the only ‘love letters’ that we know of from Fernando Pessoa; and behold them here published in their entirety for the first time. These are the facts. Just these.”

⁴ “serious content. There is also, in all of this correspondence, in spite of the false angry tone, something tragic.”

⁵ “That childish tone is not innocent. All of the commentators, starting with the editor of the Letters, David Mourão-Ferreira, have recognized that the ‘ridicule’ denounced later by Alvaro de Campos, and the tragedy that the reader can perceive between the lines, both have something to do with childhood”

Mais les critiques ne s'accordent pas sur la nature de cette explication ni sur la source de cette lumière" (357).⁶

In 1996, Ofélia's love letters were finally published. With the insight that her point of view allows, it would not be productive to make a detailed counter-argument directly with each of the scholars who analyzed the relationship while focusing only on Fernando. It is beyond a doubt that they made insightful analysis given their context, and more important than their particular analyses of the situation are the historical details they offer and the questions to which they lead. For example, Simões points out that Fernando was not a "rapaz bonito, ou másculo, ou aliciente de um ponto de vista feminino" (471).⁷ He further explains that Fernando had no experience with "qualquer intimidade amorosa com o belo sexo em época alguma da sua vida" (472).⁸ The result is that "quando, por acaso, se vê constrangido a tratar com senhoras, fecha-se mais no seu natural mutismo, respondendo ao que lhe perguntam por frases curtas, entre embaraçado e sorridente, falho de à-vontade" (472).⁹ The most important question then must be: why would this shy, inexperienced, and awkward man choose *this* woman to be his one love? How is it possible that their relationship could have lasted so long when they were so obviously ill-matched?

In what is currently the most important analysis of the love letters, Anna Klobucka bemoans the fact that until now analysis of the Pessoa/Queiroz relationship has largely ignored historical context (mainly in the person of Ofélia) and has instead relied "on the same disembodied and self-referential paradigms of textuality that have generally informed discussions of the heteronymous maze of Pessoa's literary texts" (225). She laments that even the "long-delayed publication of [Ofélia's] letters to the poet—[has] not produced any discernible critical reaction" (225). Ofélia's version of the story and her letters in context with Fernando's show that far from being a one-sided "piece of the heteronymous textual puzzle" (as most critics have hitherto seen) the affair was actually "defined by dialogic jostling of meanings allied with competing pragmatic purposes" (Klobucka 226,

⁶ "The love letters can be explained by memories of childhood, and they illuminate that childhood. But the critics in no way agree on the nature of that explanation nor on the source of that light"

⁷ "handsome young man, nor manly, nor attractive from a female point of view"

⁸ "any amorous intimacy with the fair sex at any time of his life"

⁹ "when, if necessary, he was forced to deal with women, he would close himself off even more in his natural silence, responding to what he was asked with short phrases, somewhat embarrassed and smiling, uncomfortable"

234). This “dialogic jostling of meanings” is central to the study that follows.

I believe that a better understanding of the situation lies somewhere between these two arguments. While it would be disingenuous to believe that Fernando’s heteronymic games had little to do with the relationship, it is also a major error to leave out Ofélia’s important role. By seeing the relationship through a performative framework, it is clear that the two points of view do not have to be in opposition.

Performance and Play

Jerome Bruner states that “it is far more important, for appreciating the human condition, to understand the ways in which human beings construct their worlds...than it is to establish the ontological status of the products of these processes” (46). According to Erving Goffman, one of the most important ways in which we humans construct our worlds is through performance. Goffman explains that we are all constantly performing different roles and interpreting the roles others are playing. When we meet someone, we immediately begin to gather information about that person to know what kind of play we will perform together. He states: “Information about the individual helps to define the situation, enabling others to know in advance what he will expect of them and what they may expect of him” (1). Among the elements that inform the makeup of the performance are the physical “setting” (including props) and the “manner” of the different actors, which “may be taken to refer to those stimuli which function at the time to warn us of the interaction role the performer will expect to play in the oncoming situation” (22, 24). In this way, all human beings are constantly playing in a game of character (and world) creation.

While we are constantly performing in one way or another, Johan Huizinga argues that as humans we often engage in a specific kind of performance that he calls *play*. Huizinga suggests that “[p]lay is distinct from ‘ordinary’ life both as to locality and duration” (9). Thus, one of the important characteristics of play is “its secludedness, its limitedness. It is ‘played out’ within certain limits of time and place. It contains its own course and meaning” (9). Huizinga further explains that play “proceeds within its own proper boundaries of time and space according to fixed rules and in an orderly manner. It promotes the formation of social groupings which tend to surround themselves with secrecy and to stress their difference from the common world by disguise or other means” (13). During a specific period of time, play

creates a liminal space that “begins, and then at a certain moment it is ‘over.’ It plays itself to an end. While it is in progress all is movement, change, alternation, succession, association, separation” (9).

In his work *The Anthropology of Performance*, Victor Turner draws important connections between play or what he calls *entertainment* on the one side and *liminality* on the other, when he states: “The very word ‘entertainment’ means the liminal in English, for it means literally, from the Latin, ‘to hold between,’ to be neither this nor that, but the problem in the middle—a problem which staged in liminal surrounds ‘entertains’ rather than threatens” (41). Like Huizinga, Turner believes that “the dominant genres of performance in societies at all levels of scale and complexity tend to be liminal phenomena. They are performed in privileged spaces and times, set off from the periods and areas reserved for work, food and sleep” (25). This liminal, ludic space is dominated by the language of desire, creation, and possibility, and it is in just such a space that Fernando Pessoa and Ofélia Queiroz interacted for so long.

One need not look far for proof that Pessoa lived more of his life in a creative liminal space than anyone around him. While a close examination of each example is not possible in the scope of this study I will point out that Richard Zenith, one of Pessoa’s most important translators into English, has noted that one of the salient characteristics of Pessoa’s life is that he was forever concerned with the “intellectual concerns and existential anxieties of a young man on the threshold of becoming an adult” (xvii). Zenith continues: “When he was a little boy, literature was Pessoa’s playground, and he never really left it. Like a lot of artists, but more so, Fernando Pessoa refused to grow up. He continued to live in a world of make-believe. Or shall we call it a world of make-literature?” (Zenith xxxii). Perhaps the most important intellectual part of Fernando’s “threshold” existence was the creation of a “series of characters but no play for them to act in. What they played out, in a certain way, was the life that their shy, retiring creator chose not to live in the physical world” (Zenith xxiii).

The Performance of *Hamlet*

At first glance, it is difficult to imagine how an extraordinary creative genius like Fernando Pessoa could begin and maintain relationship with such an unlikely candidate as Ofélia Queiroz. Far younger than Fernando, she was simply a 19-year-old young woman looking for work in Lisbon when she first met the shy and unassuming author. According to Ofélia, he helped her to negotiate her salary and told her later that from the moment he met her “*tinha absoluta*

necessidade de me tornar a ver” (“O Fernando e eu” 14).¹⁰ Later on in the same day, she could feel him watching her (“O Fernando e eu” 14), and not long after Fernando openly declared himself to Ofélia in the following manner:

Lembro-me que estava em pé, a vestir o casaco, quando ele entrou no meu gabinete. Sentou-se na minha cadeira, pousou o candeeiro que trazia na mão e, virado para mim, começou de repente a declarar-se, como Hamlet se declarou a Ofélia: ‘Oh, querida Ofélia! Meço mal os meus versos; careço de arte para medir os meus suspiros; mas amo-te em extremo. Oh! até ao último extremo, acredita!’ (“O Fernando e eu” 21)¹¹

He then brusquely kissed the “perturbed” Ofélia who promptly left the office. Nothing was said between the two for some time, which silence prompted Ofélia to write a letter to Fernando demanding to know his intentions with her. This was the beginning of the long and now-famous series of letters between the two.

The theatricality of this first “performance of Hamlet” (as Ofélia was to later call the scene) could not be more overstated (*Cartas de amor de Ofélia a Fernando Pessoa* 53). The fact that Pessoa must have been struck by Ofélia’s name is beyond doubt. Zenith goes so far as to wonder: “Could it have been her name that induced ultraliterary, ever-playful Pessoa to woo her in the first place?” (xxxii). While Zenith’s assumption does not seem to be out of the realm of possibility, it also does not seem sufficient explanation for the duration of the relationship. Nor does it explain why Fernando, after nine years, and in a fever of creativity, would once again respond to Ofélia’s desire to strike up the relationship. In fact, Ofélia’s letters and her recollection of the relationship prove that while her motives may have been different from Fernando’s, she was an apt creative partner for him—willingly entering into the liminal space into which he invited her with his declaration and engaging him in a performative, playful dialogue through which for a time they were able to together create possible worlds.

¹⁰ “[he] had the absolute necessity of seeing me again”

¹¹ I remember that I was standing, putting on my coat, when he entered my office. He sat down in my chair, set down a lamp that he had in his hand and, turning towards me, he suddenly began to declare his love, as Hamlet did to Ofélia: ‘O dear Ophelia! I am ill at these numbers. I have not art to reckon my groans, but that I love thee best, oh, most best, believe it!’

Donald Davidson, in his polemical essay “A Nice Derangement of Epitaphs,” discusses the way in which communication takes place at its most basic level. He claims that humans generally have “prior theories” that are conglomerations of experiences with and intuitions about language. He argues that while many philosophers and linguists argue about the nature of prior theories, they are actually unimportant because what really matters are the “passing theories” that actors must share in order to communicate: “For the passing theory is the one the interpreter actually uses to interpret an utterance, and it is the theory the speaker intends the interpreter to use. Only if these coincide is understanding complete” (261). For Davidson, communication is a process by which “as speaker and interpreter talk, their prior theories become more alike; so do their passing theories” (261).

Davidson’s theory of communication is important to understand Fernando and Ofélia’s relationship because, for Davidson, “most of the time prior theories will not be shared, and there is no reason why they should be. Certainly it is not a condition of successful communication that prior theories be shared” (262). If Zenith’s explanation that the relationship began on a whim may be true, Davidson’s theory allows us to consider how the relationship may have evolved and sustained itself. As Fernando and Ofélia communicated, their passing theories about communication became more similar, and they became collaborators in an enterprise that perhaps neither of them fully understood. Despite their many differences, Fernando and Ofélia shared an ability and willingness to communicate through the collaborative, performative play I described earlier. The production of *Hamlet* was an important moment of convergence for them.

But why *Hamlet*? As Zenith observed above, the first and most obvious answer lies in the fact that Ofélia’s name corresponds with that of Hamlet’s ill-fated lover. But the importance of *Hamlet* runs deeper than a coincidence of names. Sylvan Barnet, in his introduction to Shakespeare’s play, highlights two major philosophical questions inspired by *Hamlet* that actually apply just as well to criticism of Fernando Pessoa. Barnet’s first point deals with Pessoa’s sanity: “So many commentators on *Hamlet* have written so many words on one particular question, ‘Is Hamlet mad, or only pretending to be?’ that Oscar Wilde was moved to ask yet another question, ‘Are the commentators on Hamlet mad, or only pretending to be?’” (lxiii). The same question could certainly be asked about Pessoa. Barnet’s second point also has a Pessoaan ring to it. He states: “We are, it is sometimes said today, not unified selves, not ‘characters’ or ‘personalities,’ but rather we are mere sites traversed by the discourses to which we are exposed” (lxxxii). While Pessoa’s Ofélia must have related with

Hamlet's Ophelia on at least a superficial level, Fernando appears to have related with Hamlet on a much deeper one. The shared prior theories allowed for a moment of understanding (or misunderstanding) between the two and propelled the relationship forward.

Álvaro De Campos

The performance of *Hamlet* is also important because in a way it foreshadows one of the most interesting and perhaps puzzling elements in the epistolary relationship between Fernando and Ofélia—the presence of Álvaro de Campos. In his important study on Pessoa's South African years, Alexandrino Severino describes the privileged role that Shakespeare played in the Pessoa's heteronymic project:

Fernando Pessoa, ao referir-se à obra dramática de William Shakespeare, fá-lo quase sempre no sentido de explicar o problema da sinceridade em arte. A obra do dramaturgo inglês parece haver revelado ao poeta que toda a arte é necessariamente dramática. O maior artista seria aquele que colhesse as *mais variadas maneiras de sentir* e que mais as fingisse e simulasse. A fabricação dos heterônimos mais não é do que a tentativa de expressar diversas maneiras de sentir através de individualidades diferentes. Essa criação de personagens diversas e independentes de sua pessoa que sentissem autonomamente corresponde à definição de poesia dramática, tal qual era concebida pelo poeta. (176) [my emphasis]¹²

No heteronym searched more for a “greater variety of ways of feeling” than Álvaro de Campos who once exclaimed that he wished “To feel everything in every way, / To live everything from all sides” (Pessoa, *Fernando Pessoa & Co.: Selected poems* 146). This draws a strong correlation between Campos and Shakespeare, but there is perhaps an even stronger relationship between Campos and Hamlet.

¹² Fernando Pessoa, when referencing the dramatic work of William Shakespeare, nearly always does so in an attempt to explain the problem of sincerity in art. The work of the English dramaturg seems to have revealed to the poet that all art is necessarily dramatic. The best artist would be the one who is familiar with the *greatest variety of ways of feeling* and who best pretends and simulates them. The fabrication of the heteronyms is no more than an attempt to express diverse ways of feeling through different individualities. This creation of diverse characters who are independent of his person and who felt autonomously corresponds to the definition of dramatic poetry, just as it was conceived of by the poet. [my emphasis]

Of the myriad famous lines in *Hamlet* there is none better-known than the title character's soliloquy about suicide in which he states: "To be or not to be: that is the question" (63, 3.1). Amazingly, Álvaro de Campos, decidedly less famously and certainly a bit less poetically, exclaimed: "If you want to kill yourself, why don't you kill yourself? / Now's your chance! I who greatly love both death and life, / Would kill myself too, if I dared kill myself..." (Pessoa, *A Little Larger than the Entire Universe: Selected poems* 221). Severino draws the connection between Campos and Hamlet in the clearest of terms: "A vida e a obra dos heterônimos Ricardo Reis e Álvaro de Campos, tal como foram arquitetadas por Fernando Pessoa, têm relação com as personagens da obra dramática de William Shakespeare, especialmente com as que compõem as tragédias escritas na sua maturidade, ou seja de 'Hamlet' em diante" (204).¹³ He continues: "Álvaro de Campos protesta, de início raivosamente, a frustração do não entender o mistério do mundo. Atinge, no entanto, progressivamente, a disciplina emocional que lhe permite, como a Hamlet, viver com o seu problema, isto é, atingir uma calma indiferença" (204).¹⁴ When Pessoa, then, invokes Hamlet as he initiates his relationship with Ofélia, it is highly likely that along with playing with Ofélia's name, he is indexing his heteronymic project—especially Álvaro de Campos.

Having highlighted the above connection between Shakespeare and the heteronyms, between Hamlet and Campos, it is no surprise that from early on the heteronyms—and mainly Campos—come to play a very important role in Fernando and Ofélia's relationship. Zenith writes:

Both phases of the relationship were thwarted by a jealous Álvaro de Campos, who at one point wrote an entire letter telling Ophelia to forget about his friend Fernando, and so there was definitely—on Pessoa's side—some high literary sport going on. Ophelia was not amused, but she was willing to play the

¹³ "The life and work of the heteronyms Ricardo Reis and Álvaro de Campos, just as they were designed by Fernando Pessoa, is related to the characters of the dramatic work of William Shakespeare, especially with the tragedies written in his maturity, meaning from 'Hamlet' on."

¹⁴ "Álvaro de Campos protests, from the beginning, furiously, the frustration of not understanding the mystery of the world. He achieves, however, progressively, the emotional discipline that allows him, like Hamlet, to live with his problem, that is, to achieve a calm indifference."

game, writing a letter of reply to Álvaro in care of Fernando.
(128)

Campos's presence is so strong throughout the letters that Bréchon calls it omnipresent (359).

If Campos's presence is important in Fernando's letters, it perhaps plays an even more important role in Ofélia's. From very early on in the relationship, Ofélia appears to be more than comfortable with Pessoa's "high literary sport." In fact, she mentions Campos in writing even before Fernando does, in a letter dated March 25, 1920:

Vou-me deitar meu filho, porque são quase duas horas, (mas sempre só...) e já tenho muito sono, mas antes de fazer ó ainda vou pedir por o Sr. Crosse e por o Sr. Fernando Pessoa, pelo Sr. Álvaro de Campos não peço porque ele é maluco. Adeus meu querido amor até amanhã ao meio-dia, hora por que estou sempre ansiosa. (*Cartas de amor de Ofélia a Fernando Pessoa* 60)¹⁵

This Mr. Crosse is a reference to A.A. Crosse, another of Pessoa's heteronyms, who Fernando used to submit crossword puzzles in England. He promised Ofélia that he would use the prize money from those puzzles to marry her. The fact that Ofélia mentions Crosse, Pessoa, and Campos in the same playful phrase appears to indicate that she was part of the game and enjoyed it—more as a collaborator than a victim. Campos at times appears as a sort of whipping boy for Ofélia when she wants to chastise Fernando, as is seen in another letter—this one from June 4, 1920: Ainda bem que o Sr. Crosse está de saúde mas ele que tenha cuidado com o vinho da Madeira e o Sr. Álvaro de Campos com o balde se ele não sabe nadar morre afogado, coitadinho... (Queiroz, *Cartas de amor de Ofélia a Fernando Pessoa* 71).¹⁶ While not discounting the frustration that Ofélia may have felt with Fernando's changing of characters, it is at least plausible that at this stage in the relationship it was more a source of amorous banter

¹⁵ I am going to bed my son, because it is now almost two o'clock, (but it always is ...) and I am now very tired, but before I do so I am going to ask for Mr. Crosse and for Mr. Fernando Pessoa, and for Mr. Álvaro de Campos I will not ask because he is mad. Farewell my dear love until tomorrow at midday, the hour for which I am ever anxious.

¹⁶ "Even though Mr. Crosse is in good health he must be careful with the Madeira wine and Mr. Álvaro de Campos with the bucket if he does not know how to swim he will drown to death, careful."

than of real friction. In “O Fernando e eu,” Ofélia described Campos’s interventions in the following terms:

Por exemplo, o Fernando era um pouco confuso, principalmente quando se apresentava como Álvaro de Campos. Dizia-me então:—‘Hoje, não fui eu que vim, foi o meu amigo Álvaro de Campos’...Portava-se nestas alturas de uma maneira totalmente diferente. Destramelhado, dizendo coisas sem nexos. Um dia, quando chegou ao pé de mim, disse-me:—“Trago uma incumbência, minha Senhora, é a de deitar a finisnomia abjecta desse Fernando Pessoa, de cabeça para baixo num balde cheio de água”. E eu respondia-lha: “— Detesto este Álvaro de Campos. Só gosto do Fernando Pessoa”.—“Não sei porquê—respondu-me—olha que ele gosta muito de ti”. (“O Fernando e eu” 37)¹⁷

Notwithstanding her admitted confusion at Fernando’s games, Ofélia appears to have kept pace remarkably well, playing along and collaborating with the poet.

One of Fernando’s most famous (and perhaps misunderstood) letters is the one Zenith referred to above, written by Campos and addressed to Ofélia:

Exma. Senhora D. Ophelia Queiroz:
Um objecto e miseravel individuo chamado Fernando Pessoa,
meu particular e querido amigo, encarregou-me de commu-
nicar a V. Ex.a—considerando que o estado mental d’elle o
impede de communicar qualquer coisa, mesmo a uma ervilha
secca (exemplo da obediencia e da disciplina)—que V. Ex.a
está prohibida de:
 pesar menos grammas,
 comer pouco
 não dormir nada

¹⁷ For example, Fernando was a bit confusing, principally when we would present himself as Álvaro de Campos. He would say to me then: ‘Today, it was not me who came, it was my friend Álvaro de Campos’ ... He acted at these times in a totally different manner. Scatterbrained, saying meaningless things. One day, when he came to me, he told me: ‘I have a task, my lady, it is that of knocking down the abject physiognomy of this Fernando Pessoa, from head to toe in a bucket full of water.’ And I would tell him: ‘I hate this Álvaro de Campos. I only like Fernando Pessoa.’ ‘I do not know why,’ he told me, ‘considering that he likes you quite a lot.’

ter febre

pensar no individuo em questão

Pela minha parte, e como intimo e sincero amigo que sou do meliante de cuja comunicação (com sacrificio) me encargo, aconselho V. Ex.a a pegar na imagem mental, que acaso tenha formado do individuo cuja citação está estragando este papel razoavelmente branco, e deitar essa imagem mental na pia, por ser materialmente impossivel dar esse justo Destino á entidade fingidamente humana a quem elle competiria se houvesse justiça no mundo.

Cumprimenta V. Ex.a

Alvaro de Campos

eng. naval

25/9/1929 (Pessoa, *Cartas de amor* 145)¹⁸

When seen on its own, it is hard to imagine this letter being anything other than a cruel and misogynistic joke played by Fernando—perhaps to get her to break off the relationship. But it is important to see the letter in its context. I have previously shown how Ofélia was already very familiar with Campos as a character and in fact had already interacted with him on various occasions. Furthermore, this Campos letter actually comes as a response to one written by Ofélia earlier on the same day in which she states the causes for her ill health:

¹⁸ Most Excellent Ms. D. Ophelia Queiroz:

An abject and miserable individual called Fernando Pessoa, my particular and dear friend, asked me to tell your excellency—considering that his mental state impedes his communicating anything to you [...]—that your excellency is prohibited from:

weighing more

eating little

not sleeping at all

having a fever

thinking about the individual in question

For my part, and as the intimate and sincere friend of the scoundrel for whose communication (with sacrifice) I take responsibility, I encourage your excellency to take this mental image, that you might have of the individual whose citation is spoiling this reasonably white paper, and to put that image in the sink, because it is materially impossible to give this just Destiny to the falsely human entity with whom he would compete if there were justice in the world.

Compliments to your excellency

Alvaro de Campos

Naval Engineer

9/25/1929 (Pessoa, *Cartas de amor* [Pessoa, *Love Letters*] 145)

Não posso por muito tempo continuar a comer como ultimamente, pois que além de adoecer, fico muito feia, muito magra de mais e o Fernandinho depois não gosta de mim. Agora a noite é que passei pessimamente, quase toda a noite acordada. Calcule que me deitei erna pouco mais das 11 h, e eram 2 1/2 ainda não tinha conseguido dormir. Dei tanta volta, tanta tanta, que estava maçadíssima [...] De manhã parece que tinha a cabeça aberta. Quem é o responsável? O Fernandinho, porque me não sai do pensamento. Penso no presente, penso no futuro... o Fernandinho ocupa quase por completo a minha vida, e ainda o Fernandinho diz que sou vespa, mas não sou sua. Sou sim, meu amor, sou muito sua. (Queiroz, *Cartas de amor de Ofélia a Fernando Pessoa* 205)¹⁹

Fernando writes to Ofélia, not in a cruel but a playful way—concerned for her well-being and addressing specifically each of her stated ailments. Ofélia's response to Campos's letter shows just how well she was able to play the game and reveals her principal gripe with the engineer:

Ex.mo Senhor Engenheiro Álvaro de Campos
 Permita-me que discorde por completo com a primeira parte da sua carta, porque, nem posso consentir que Va Exa trate o Ex.mo Sr. Fernando Pessoa, pessoa quem muito prezo, por abjecto e miserável indivíduo nem compreendo que, sendo seu particular e querido amigo o possa tratar tão desprimorosamente.
 Como vê estamos sempre em completa desarmonia, nem podia deixar de ser, pedindo-lhe por especial fineza, que não volte a escrever-me. Quanto às observações que me faz, como foram ditadas pelo Sr. Fernando Pessoa, farei quanto em mim caiba por lhe ser agradável.

¹⁹ For a long time I have been unable to eat as I usually do, and besides becoming ill, I am getting very ugly, too thin, and then Fernando won't like me. Last night was terrible. Think that I went to bed just after 11pm, and at 2:30 and I still had not slept. I tossed and turned, it was such a nuisance [...] In the morning it felt like my head was split open. Who is responsible? Little Fernando, because he does not leave my thoughts. I think about the present, I think about the future ... little Fernando nearly completely occupies my life, and still little Fernando thinks I am a wasp, but I am not his. But I am, yes, my love, I am his.

Agradeço o conselho que me dá, mas já que me puxa pela língua, deixe-me dizer-lhe que quem eu de boa vontade há muito tempo teria, não deitado na pia, mas debaixo dum comboio, era Va Exa.

Esperando não o tornar a ler, subcreve-se com respeito a
26-9-929

Ofélia Queiroz. (*Queiroz, Cartas de amor de Ofélia a Fernando Pessoa* 208)²⁰

The letter shows that Ofélia's concern with the bucolic Campos was not that he treated her poorly, but that he had an adverse effect on Fernando. It also shows her strength of character in placing limits on the game they were playing while still remaining firmly inside it.

Her follow-up letter to Fernando, chastising him for the letter, shows the same thing:

Que triste ideia teve em encarregar o Sr. Engenheiro Álvaro de Campos de escrever-me? Ele afinal não é seu amigo, trata-o tão mal! E não sendo seu amigo também o não é meu, e não sendo meu amigo eu também não sou amiga dele, portanto não gosto dele, detesto-o pronto. Peço-lhe meu querido Fernandinho que não volte a encarregá-lo de me escrever, e que por fineza lhe entregue a minha carta, que por não saber a sua direcção junto à sua. Ele afinal só pretende desacreditá-lo, mas

²⁰ Most excellent Engineer Álvaro de Campos

Allow me to disagree completely with the first part of your letter, because neither can I consent that your excellency treat his excellency Mr. Fernando Pessoa, a person whom I greatly prize, as an abject and miserable individual, nor do I comprehend how, being his particular and dear friend you can treat him so nonsensically.

As you can see we are always in complete disharmony, nor can I do anything besides ask you with special grace, that you not write me again. As for the observations that you make of me, since they were dictated to you by Mr. Fernando Pessoa, I will do whatever I can to be agreeable.

I thank you for your counsel, but since you are pulling me with your tongue, let me tell you that the one I would truly like to have, not in a sink, but under a train, is your excellency.

Hoping not to read from you again, writing with respect this
9-26-929

Ofélia Queiroz.

eu não o poupo, e decerto não me escreverá mais. (*Cartas de amor de Ofélia a Fernando Pessoa* 208)²¹

The obedient Fernando never asked Campos to write to Ofélia again. But from this point on the relationship does seem more strained and Fernando quickly begins to write fewer and fewer letters, one of which provides valuable insight into Fernando's mind.

On the 26th of September, 1929, Fernando writes to Ofélia to let her know that he won't be able to see her that day because he will be forced to spend the entire day with Campos (Pessoa, *Cartas de amor* 147). On the 27th, she writes back telling him that she is nervous about their relationship and that she wants to marry him. She also writes: "Vamos a ver se amanhã, recebo uma cartinha sua, mas uma cartinha agradável, em que se não note a intervenção do Sr. Engenheiro" (Queiroz, *Cartas de amor de Ofélia a Fernando Pessoa* 211).²² Fernando responds with a tender and sincere effort to try to help Ofélia understand him better:

Toda a minha vida futura depende de eu poder ou não fazer isto, e em breve. De resto, a minha vida gira em torno da minha obra litteraria—boa ou má, que seja, ou possa ser. Tudo o mais na vida tem para mim um interesse secundario: ha coisas, naturalmente, que estimaria ter, outras que tanto faz que venham ou não venham. É preciso que todos, que lidam commigo, se convençam de que sou assim, e que exigir-me os sentimentos, aliás muito dignos, de um homem vulgar e banal, é como exigir-me que tenha olhos azues e cabelo louro. E estar a tratar-me como se eu fôsse outra pessoa não é a melhor maneira de manter a minha affeição. É preferível tratar assim

²¹ What sad idea did you have in asking the engineer Mr. Álvaro de Campos to write to me? In the end he is not your friend. He treats you so poorly! And since he is not your friend, he is also not mine, and since he is not my friend I am also not his friend, therefore I do not like him, I detest him in fact. I ask you, my dear little Fernando, that you to ask him to not write to me again, and that you be so kind as to give him my letter, since I do not know his address. In the end he just wants to discredit you, but I do not worry about it, and surely he will never write to me again.

²² "Let us see if tomorrow I receive a note from you, but an agreeable note, in which the intervention of the engineer is not noted"

quem seja assim, e nesse caso é ‘dirigir-se a outra pessoa’ ou qualquer phrase parecida. (*Cartas de amor* 150)²³

Despite his strong words of warning to her, he also encourages Ofélia with perhaps his most sincere statement of the relationship:

Gosto muito—mesmo muito—da Ophelinha. Aprecio muito—muitíssimo—a sua indole e o seu character. Se casar, não casarei senão consigo. Resta saber se o casamento, o lar (ou o que quer que lhe queiram chamar) são coisas que se coadunem com a minha vida de pensamento. Duvido. Por agora, e em breve, quero organizar essa vida de pensamento e de trabalho meu. Se a não conseguir organizar, claro está que nunca sequer pensarei em casar. Se a organizar em termos de ver que o casamento seria um estorvo, claro que não casarei. Mas é provavel que assim não seja. O futuro—e é um futuro proximo—o dirá. (*Cartas de amor* 150—51)²⁴

His final goodbye, with echos of Campos, has a tragic tenderness to it: “Ora ahi tem, e, por acaso é a verdade. / Adeus, Ophelinha. Durma e coma, e não perca grammas. / Seu muito dedicado, Fernando” (*Cartas de amor* 151).²⁵

²³ All of my future life depends on my being able to do this or not, and quickly. My life revolves around my literary work—good or bad, what is, or what will be. Anything or everything else in life has only secondary interest: there are things, naturally, that I would like to have, others that I do not care if they come or not. It is necessary that all those who work with me, be convinced that this is the way I am, and that to ask me to have the feelings, though they be very dignified, of a vulgar and banal man, is like asking me to have blue eyes or blond hair. And treating me as if I were another person is not the best way to maintain my affection.

²⁴ I really like—quite a lot—little Ophelia. I greatly appreciate—greatly—her nature and her character. If I get married, I will not marry anyone but her. It remains to be seen if marriage, home (or whatever they want to call it) are compatible with my life of thought. I doubt it. For now, to be brief, I want to organize this life of thought and my work. And if I am unable to organize, it is clear that I will never even think about getting married. If I organize it and find that marriage would be a bother, I clearly will not marry. It probably will not be so. The future—and it is a close future—will tell.

²⁵ “For now have this, and, maybe it is true. / Farewell, little Ophelia. Eat and sleep, and do not lose any grams. / Your very dedicated, Fernando”

Conclusion

Notwithstanding Ofélia's affirmation: "Eu esperarei pelo Fernandinho o tempo que for necessario" (*Cartas de amor de Ofélia a Fernando Pessoa* 214),²⁶ it becomes quickly clear that Fernando is not going to be able to organize his mental life in the way that Ofélia hopes he will. She continues to write him faithfully, sometimes lovingly, sometimes desperately, sometimes angrily, but by mid-October he has all but completely stopped writing to her (although they continue to see each other for some time). Ofélia remains convinced that Campos has forbidden Fernando to write to her and she pleads with Fernando to send the engineer back to England (*Cartas de amor de Ofélia a Fernando Pessoa* 226). But Fernando's epistolary silence is definite.

Up to this point, Ofélia's testimony about the events of her relationship appear to follow fairly closely the epistolary record. But there is one major discrepancy that must be pointed out in conclusion. Ofélia claims that toward the end of their relationship she stopped writing to Fernando because his letters were no longer answerable: "De resto, já não respondi às suas últimas cartas porque achei que já não eram para responder. Não valia a pena. Sentia que já não tinham resposta" (Queiroz, "O Fernando e eu" 42).²⁷ The painful reality, however, is that she continued to write to Fernando from November 1929 (the date of Fernando's last missive to her) until December 1932—over three years—begging him to write to her and to stop drinking, but also continuing to fantasize about her possible future life with Fernando. She imagines a child they would have together, "little Fernando," and she imagines entire daily routines for their little family (Queiroz, *Cartas de amor de Ofélia a Fernando Pessoa* 320—21). Apparently they also continued to see and to call on each other during much of this time, but Fernando seems to have grown tired of writing to her, tired of the game.

Despite the unceremonious end of the relationship, for a period of time Fernando Pessoa and Ofélia Queiroz worked remarkably well together, sharing and collaborating to create meaning through imagined worlds. Multiple questions remain to be asked about the relationship, and many other examples could be used to illustrate the ways in which Fernando participated in Ofélia's imagined worlds just as much as she did in his. One thing remains clear: the love letters are absolutely

²⁶ "I will wait for little Fernando for as long as might be necessary"

²⁷ "In the end, I no longer responded to his last letters because I thought that there was nothing to say. It was not worth it. I felt there could be no response"

fundamental to an understanding of Fernando's physical and mental worlds, and no study of the love letters can be considered complete without the inclusion of Ofélia's letters alongside Fernando's nor without a careful study of how their relationship was shaped by performance, collaboration, and play.

Bibliography

Barnet, Sylvan. "Introduction." *The Tragedy of Hamlet, Prince of Denmark*. New York: Penguin, 1998. lxiii–xcii. Print.

Bréchon, Robert. *Etrange Étranger: une Biographie de Fernando Pessoa*. Paris: Bourgois, 1996. Print.

Bruner, Jerome S. *Actual Minds, Possible Worlds*. Cambridge: Harvard UP, 1986. Print.

Davidson, Donald. "A Nice Derangement of Epitaphs." *The Essential Davidson*. Oxford: Clarendon; Oxford UP, 2006. 251–65. Print.

Goffman, Erving. *Presentation of Self in Everyday Life*. New York: Anchor, 1999. Print.

Huizinga, Johan. *Homo Ludens a Study of the Play-Element in Culture*. Boston: Beacon, 1955. Print.

Klobucka, Anna. "Together at last: reading the love letters of Ophelia Queiroz and Fernando Pessoa." *Embodying Pessoa: Corporeality, Gender, Sexuality*. ed. Anna Klobucka & Mark Sabine. Toronto: U of Toronto P, 2007. 224–41. Print.

Mourão-Ferreira, David. "Estas 'Cartas de amor' de Fernando Pessoa." *Cartas de Amor de Fernando Pessoa*. Lisbon: Atica, 1978. 177–222. Print.

Pessoa, Fernando. *A Little Larger than the Entire Universe: Selected Poems*. New York: Penguin, 2006. Print.

—. *Cartas de amor de Fernando Pessoa*. Lisbon: Atica, 1978. Print.

—. *Fernando Pessoa & Co.: Selected poems*. 1st ed. New York: Grove, 1998. Print.

Queiroz, Ofélia. *Cartas de Amor de Ofélia a Fernando Pessoa*. ed. Maria da Conceição Azevedo & Manuela Nogueira. Lisboa: Assírio & Alvim, 1996. Print.

—. “O Fernando e eu.” *Cartas de Amor de Fernando Pessoa*. ed. Maria da Graça Queiroz. Lisboa: Edições Atica, 1978. 9–44. Print.

Severino, Alexandrino. “Shakespeare e Pessoa: Um estudo parcial de influência.” *Fernando Pessoa na África do Sul: A Formação Inglesa de Fernando Pessoa*. 1st ed. Lisbon: Dom Quixote, 1983. 175–205. Print.

Shakespeare, William. *The Tragedy of Hamlet, Prince of Denmark*. ed. Sylvan Barnet. New York: Penguin, 1998. Print.

Simões, João. *Vida e Obra de Fernando Pessoa: Historia Duma Geracao*. Lisboa: Livraria Bertrand, 1950. Print.

Turner, Victor. *The Anthropology of Performance*. Vol. 1. New York: PAJ, 1986. Print.

Zenith, Richard. “Introduction: The Birth of a Nation.” *A Little Larger than the Entire Universe: Selected Poems*. New York: Penguin, 2006. xiii–xxxii. Print.

Qualifying and Quantifying the Uncertainty in the Heisenberg Uncertainty Relations

Jacob “J” Collings and Jean-François S. Van Huele
Brigham Young University

Abstract

When Heisenberg introduced the relation $p, q, \sim \hbar$ in 1927, he brought the concept of uncertainty into the description of quantum physics and an awareness that stringent limitations apply in the quantum world. Recent work has shown that the term ‘uncertainty’ applies to two different quantum properties. The first pertains to preparation uncertainty, the principle that one cannot prepare a quantum system such that two incompatible observables are arbitrarily well-defined. The second pertains to measurement uncertainty, the principle that the measurement with a certain degree of accuracy of one observable disturbs the subsequent measurement of a second incompatible observable. We review recent proposals for a reformulation of the uncertainty principle, discuss experiments showing evidence for a violation of the measurement uncertainty, and illustrate the different relations with specific examples using spin measurements.

I. INTRODUCTION

In 1927, Heisenberg introduced a thought experiment concerning a γ -ray microscope [1]. In this thought experiment, Heisenberg has us picture an electron having its position measured by means of a photon (Figure 1). When the photon collides with the electron, it provides an accurate measurement of the electron's position; however, the collision jolts the electron, causing its momentum to be disturbed. Conversely, if we were to measure the momentum of the electron, its position would be disturbed by the photon used to measure it. This principle—that one cannot measure the position of a quantum system without disturbing its momentum, and vice versa, is what is called the Heisenberg Uncertainty Principle—and the corresponding quantitative relation is known as the Heisenberg Uncertainty Relation (HUR). This relation has been a fundamental ingredient of quantum mechanics ever since. In fact, arguably the HUR has become one of the most well-known features of quantum physics. It is obedience to this law that allows us to set the limits as we perform calculations in quantum systems. For years, this relation has set the bar for the maximum precision with which experimentalists can prepare their quantum systems, as well as measure any quantum states. Recently, both the significance and the precise form of the relation have been called into question. The purpose of our contribution is to explain the different ways to state the HUR, make the connection with recent experimental tests, and illustrate our point with an example based on the measurement of spin. In what follows, no fundamentally new results are derived, but the importance of the distinction we establish between what we will call preparation uncertainty and measurement uncertainty can hardly be overstated.

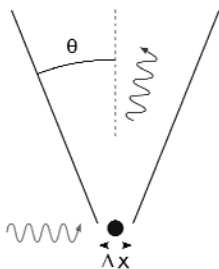


FIG. 1: Heisenberg's γ -ray microscope thought experiment. Here, the incoming γ -ray (grey wavy line) scatters against the electron (\bullet), producing a position measurement with the scattered γ -ray (black wavy line). The more precise the position measurement, the stronger the γ -ray disturbs the momentum of the electron.

When Heisenberg first proposed this relation, which he wrote as $p_1 q_1 \sim h$, he supported his thought experiment with a mathematical proof. The derivation, worked out in a more modern quantum language, is presented in many quantum text books [2] and leads to the iconic $\Delta x \Delta p \geq \frac{\hbar}{2}$. It states that the product of the standard deviation of momentum (Δp) and the standard deviation of position (Δx) are bounded by a lower limit proportional to Planck's quantum of action h with $\hbar = \frac{h}{2\pi}$. In the original expression, Heisenberg calls p_1 and q_1 the precisions with which the momentum and the position are known.

The inverse proportional relation between the uncertainties in position and momentum has been illustrated and verified experimentally, for example by Nairz et al. [3] in an experiment where the lower bound of the HUR was found when sending beams of fullerene molecules C_{70} through a narrow slit.

Recently, however, two new types of quantum measurement have brought the validity of the original HUR into question; namely, weak measurement [4] and triple-state measurement [5]. By taking advantage of quantum mechanical properties, these two measurement techniques are, in principle, capable of making a physical measurement without creating any disturbance. Triple-state measurement accomplishes this by making three distinct measurements of a system. Each measurement is precisely arranged such that whatever disturbance is caused by the first measurement is cancelled out by the second and third measurements. This is done by varying the measurement angle between the two incompatible observables being measured. In a completely different fashion, it is possible to make very weak measurements that do not collapse the system. The measurement will produce a result with often very large error, but when done numerous times, the expectation value of the measurements are taken and results in a highly accurate measurement with no disturbance. Although the two techniques utilize completely different quantum mechanical properties, they both succeed in accomplishing a disturbance-free measurement.

It is in light of these two measurement techniques that the HUR unravels. When referencing a physical measurement, the HUR is written in terms of the error of the measurement ε and the disturbance of the incompatible observable η . The relation is written $\varepsilon(A)\eta(B) \geq \frac{\hbar}{2}$, where A is the observable being measured and B is the incompatible observable being disturbed. In the case of weak or triple-state measurements, η will be zero. In this instance, we obtain $0 \geq \frac{\hbar}{2}$, since the left-hand side is simply a product. Thus, in the case of a weak

or triple-state measurement leading to no disturbance, the HUR is violated.

In 2003, Ozawa [6] noticed how the HUR could be violated if either the error or the disturbance would approach zero. He proposed the reformulation

$$\epsilon(A)\eta(B) + \epsilon(A)\sigma(B) + \sigma(A)\eta(B) \geq \frac{1}{2}|\langle[A, B]\rangle|, \quad (1)$$

where $\langle \dots \rangle$ refers to the quantum mechanical expectation value [2] and σ represents the standard deviation—the same σ we recognize as appearing in the modern expression of the HUR (as shown in Eq. (3)). Ozawa chose to include not only the error and disturbance of the system, but also the standard deviation of each observable. By doing this, the left-hand side will never go to zero. Ozawa's reformulation of the HUR did not catch the interest of many, until several experimental researchers validated Ozawa's claims [7–9].

This in turn has led others [10, 11] to reformulate the HUR. In particular, Branciard produced a relation [12] that draws upon the key concepts of Ozawa's formulation, but extends it to provide the tighter relation

$$\left[\epsilon^2(A)\sigma^2(B) + \sigma^2(A)\eta^2(B) + 2\epsilon(A)\eta(B)\sqrt{\sigma^2(A)\sigma^2(B) - \left(\frac{1}{2}|\langle[A, B]\rangle|\right)^2} \right]^{\frac{1}{2}} \geq \frac{1}{2}|\langle[A, B]\rangle|. \quad (2)$$

The lower bound of Branciard's relation is greater than Ozawa's, providing a stricter, 'tighter' relation, while still remaining valid. The tightness of Branciard's relation, as compared to Ozawa's and Heisenberg's, can be seen in Fig. 2.

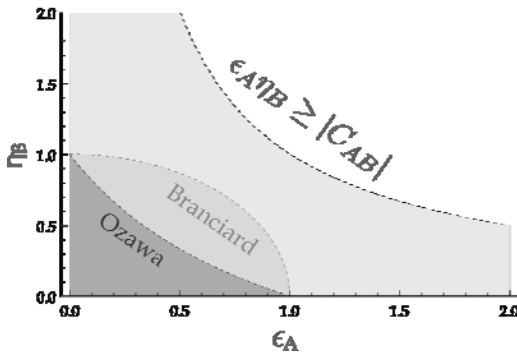


FIG. 2: Lower bounds for the HUR (light grey), Ozawa's reformulation (dark grey), and Branciard's reformulation (medium grey). The shaded regions show the 'forbidden zones,' the quantities that fall below the lower limit of the relations. The quantity $|C_{AB}|$ in the figure is the right-hand side of the relation (2), namely $\frac{1}{2}|\langle[A, B]\rangle|$.

II. HUR IN A STATE OF FLUX

Not everyone agrees that the original HUR is violated. It has been argued [13] that Ozawa's reformulation misinterprets Heisenberg's original meaning. With no proper physical interpretation, Ozawa's relation would thus be mathematically sound, yet meaningless in practicality.

In response, various experimental groups have provided evidence, using weak [8, 9] and triple-state measurement [7] techniques. All of these experiments found results within the forbidden zones of the HUR (see Fig. 3). However, as stated earlier, Nairz et al. provided physical evidence supporting the HUR. The solution to this paradoxical situation is the following: both are correct. The HUR does hold, as has been claimed, and yet it is violated, as others have claimed. This is made possible because, although both the HUR and Ozawa's formulations concern uncertainty of a quantum state, they are addressing two completely different physical properties of the quantum state. It is necessary to refine our definition of quantum uncertainty; namely, by separating what was once covered by the HUR into two definitions: preparation uncertainty and measurement uncertainty.

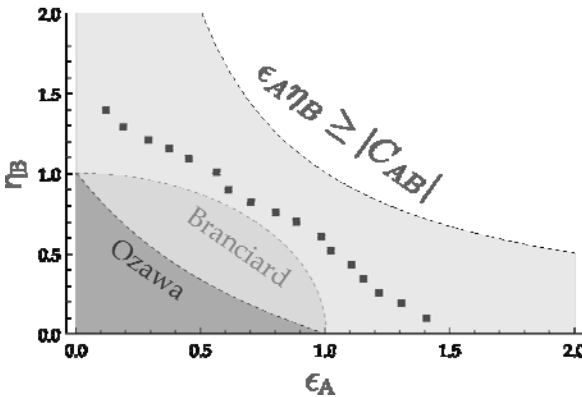


FIG. 3: Results of a triple-state measurement by Ringbauer et al. [14], clearly indicating a violation of the Heisenberg Uncertainty Relation.

III. UNDERSTANDING UNCERTAINTY

Heisenberg's original mathematical proof of his uncertainty relation involved two variables, the canonical position q and the canonical momentum p , and an expression for the minimum uncertainty containing Planck's fundamental quantum of action h .

Today, the more common format for the relation between arbitrary incompatible observables A and B is [15]

$$\sigma_A \sigma_B \geq \frac{1}{2} |\langle [A, B] \rangle|, \quad (3)$$

where σ is the standard deviation of the corresponding observable, $[A, B]$ is the commutator of A and B, and $\langle A \rangle$ is the expectation value of A. The standard deviation is given as usual by

$$\sigma_A = \sqrt{\langle A^2 \rangle - \langle A \rangle^2}. \quad (4)$$

While standard deviation is a well-known and well-defined statistical property, Heisenberg did not use standard deviation to qualitatively define his uncertainty relation. In his thought experiment, Heisenberg referenced an error and a disturbance that occurs from a physical measurement. For many years, standard deviation has been the accepted mathematical interpretation for the physical properties of error and disturbance. However, Ozawa argued [6] that a more accurate definition for error and disturbance was needed. He defined error and disturbance as

$$\epsilon \equiv \langle (U^\dagger(\mathbb{1} \otimes M)U - A \otimes \mathbb{1})^2 \rangle^{\frac{1}{2}}, \quad (5)$$

and

$$\eta \equiv \langle (U^\dagger(B \otimes \mathbb{1})U - B \otimes \mathbb{1})^2 \rangle^{\frac{1}{2}}. \quad (6)$$

Here, ϵ is error, η is disturbance, A and B are incompatible observables, M is the measurement probe, and U is a unitary transform representing the interaction between the probe and the system. These definitions of error and disturbance are quite different from the standard deviation definitions normally used. While standard deviation is a static value that relies entirely upon the nature of the observable and the state it is calculated in, error and disturbance are dynamic properties, and result from the physical interaction between system and probe, in addition to depending on the state of the system and the observable being measured.

IV. PREPARATION UNCERTAINTY

We define preparation uncertainty as the property that one cannot prepare a quantum system such that two incompatible observables are arbitrarily well defined. This is the uncertainty found in the quantum textbooks [2, 16]. For example, when preparing a spin-system with a high degree of certainty in its z-component, the x-component and y-

component of the spin will both have degraded certainty in this prepared state. This trade-off of certainty in a state's preparation is the preparation uncertainty.

Mathematically, preparation uncertainty is defined as in Eq. (3). Experimentally, the relation was shown for the case of position and momentum by Nairz et al [3]. This relation remains valid: Preparation uncertainty is not being called into question. Reformulations to the HUR are not needed for preparation uncertainty. When Heisenberg first produced his uncertainty relation, he actually proved the preparation uncertainty using Gaussian states. By doing so, Heisenberg moved away from his original thought experiment. When we mention Heisenberg's original relation and his thought experiment, we are referring to two different types of uncertainty. The thought experiment portion of Heisenberg's microscope dealt with measurement uncertainty.

V. MEASUREMENT UNCERTAINTY

We define measurement uncertainty as the principle that the measurement with a certain degree of accuracy of one observable disturbs the subsequent measurement of a second incompatible observable. This uncertainty pertains to physical measurements only; it is not limited to the original state of the system. For example, when measuring the z-component of the spin, one disturbs the x-component and the y-component. Not only will the measurement have a degree of error in the z-component, but the x- and y-components will no longer be found in the same state as they were at measurement. Their values will be disturbed and will no longer be recoverable. To reduce this disturbance, one would have to increase the allowed error in the z-component.

If we were to express the measurement uncertainty in the same mathematical form as preparation uncertainty, we would get

$$\epsilon_A \eta_B \geq \frac{1}{2} |\langle [A, B] \rangle|, \quad (7)$$

where E is the error of the measurement and η is the disturbance of the second, incompatible observable. While the relation has the same simple form as preparation uncertainty, the crucial difference comes in the definition of error and disturbance, as given in Eqs. (5) and (6).

These definitions for error and disturbance are much more in line with what Heisenberg discussed in his original thought experiment; however, we see that having a zero disturbance causes a breakdown of the relation as the right-hand side, being non-zero, cannot be smaller

than the left-hand side. This is also true for any situation wherein the error is zero, although any possible means of performing such a measurement are, as of yet, unknown.

As previously stated, this measurement uncertainty is what Heisenberg had in mind with his thought experiment. However, when Heisenberg first conceived this experiment, he did not account for the ability to have zero disturbance.

VI. MEASUREMENT UNCERTAINTY REFORMULATIONS

In light of the development of zero-disturbance measurements, we need a new relation for measurement uncertainty. Ozawa was first to propose a new uncertainty relation, although in his original paper, he suggested replacing the HUR as a whole. Noticing that having either error or disturbance as zero would invalidate the HUR, Ozawa proposed revising the relation to

$$\epsilon(A)\eta(B) + \epsilon(A)\sigma(B) + \sigma(A)\eta(B) \geq \frac{1}{2}|\langle[A, B]\rangle|. \quad (8)$$

Here, Ozawa introduces the σ terms from preparation uncertainty into the measurement uncertainty relation. Thus, when either error or disturbance is zero, the product terms with σ prevent the left-hand side from going to zero, resulting in a nonviolated relation. Introducing preparation uncertainty to the measurement uncertainty makes sense; the degree of accuracy by which one can measure the system will be impacted by how well the state is prepared before making the measurement.

Branciard later noticed that Ozawa's relation was not universally valid and did not provide the tightest relation [12]. Using Ozawa's work as a starting point, Branciard produced a new relation

$$\left[\epsilon^2(A)\sigma^2(B) + \sigma^2(A)\eta^2(B) + 2\epsilon(A)\eta(B) \sqrt{\sigma^2(A)\sigma^2(B) - \left(\frac{1}{2}|\langle[A, B]\rangle|\right)^2} \right]^{\frac{1}{2}} \geq \frac{1}{2}|\langle[A, B]\rangle|. \quad (9)$$

Like Ozawa, Branciard includes the preparation uncertainty factors; however, Branciard also introduces the preparation uncertainty limit into the left-hand side to compensate for a nonminimized preparation uncertainty.

As we explain in Section VII, these reformulations have since been verified experimentally. We now review four different experiments using both triple-state and weak measurements to validate the necessity of these reformulations.

VII. EXPERIMENTAL EVIDENCE OF THE MEASUREMENT UNCERTAINTY

We take the results of four different experiments—Erhart et al. [7] and Ringbauer et al. [14] used triple-state measurement techniques, while Rozema et al. [8] and Kaneda et al. [9] used weak measurement techniques—and compile the data into four error vs. disturbance graphs (see Fig. 4). As the data show, when using the traditional HUR, every one of the four experiments results in a violation of the HUR; however, when we take into account our new definitions for measurement uncertainty and then apply the proposed relations of Ozawa or Branciard, we find that the data are within the bound. This is due to the dynamic nature of measurement uncertainty; we simply cannot use the static properties of preparation uncertainty to calculate the dynamic uncertainty inherent in a physical measurement when those measurements contain a near-zero disturbance.

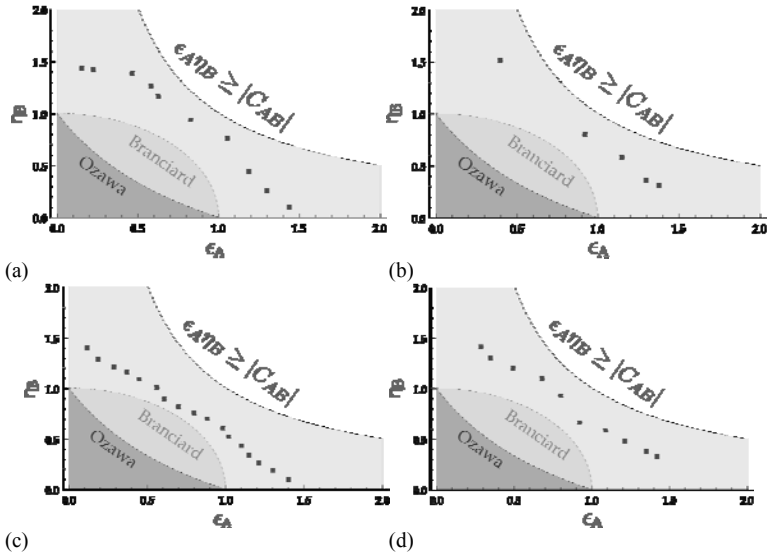


FIG. 4: Experimental data and uncertainty relations. For the data obtained by (a) Erhart et al. [7], (b) Rozema et al. [8], (c) Ringbauer et al. [14], and (d) Kaneda et al. [9], the Heisenberg relation is clearly violated while the Ozawa and Branciard relations still hold. The quantity $|CAB|$ in the figure is the right-hand side of the relations (1)-(3) and (8)-(9), namely $\frac{1}{2} |\langle [A, B] \rangle|$.

VIII. SIMULATING WEAK MEASUREMENTS

To further illustrate the nature of uncertainty, we simulate a weak measurement setup as proposed by Lund and Wiseman [4]. We refer to their publication for the justification and details of this particular setup. The z- resp. x-component of spin are simulated by constructing CNOT (Control-NOT) gates as unitary transform U_1 resp. U_2

$$U_1 \equiv \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix} \quad (10)$$

$$U_2 \equiv \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \end{pmatrix}. \quad (11)$$

The CNOT gate involves, as the measurement process should, both the system and the probe, and in such a way that the weak probe is affected by the system but without causing any disturbance itself. We choose A to be the observable that we are measuring and B to be the observable that is disturbed. First, we find the error of a Z measurement with a disturbance in X . We set our probe M to be in the Z state to get a direct measurement. To better see the effect of measurement strength, we choose for an input ψ a meter in Y with a measurement from Z to X that varies in strength according to θ , which can vary between 0 and $\pi/4$. With a spin prepared in the y -component, we are able to achieve the maximum degree of uncertainty. This is important: By maximizing the possible uncertainty, we make sure to check each relation at the greatest extreme possible. Doing so gives

$$\epsilon(Z) = \langle \psi | (U_1^\dagger (\mathbb{1} \otimes Z) U_1 - Z \otimes \mathbb{1})^2 | \psi \rangle^{\frac{1}{2}},$$

with

$$\psi = \frac{1}{\sqrt{2}} \begin{pmatrix} \cos(\theta) \\ \sin(\theta) \\ i \cos(\theta) \\ i \sin(\theta) \end{pmatrix}$$

for the meter, where $\langle \psi | \alpha | \psi \rangle$ is the expectation value of α . Since $\mathbb{1}$ is the identity matrix and Z is the Pauli matrix for a spin- $\frac{1}{2}$ in the z direction, we find that

$$\mathbb{1} \otimes Z = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$$

and

$$Z \otimes \mathbb{1} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}.$$

We simulate the weak measurement using the U_1 CNOT gate as a unitary transform on the probe. We define Q_ϵ as

$$Q_\epsilon = U_1^\dagger (\mathbb{1} \otimes Z) U_1, \quad (12)$$

Here, Q_ϵ is the actual result measured by the probe. To find the error, we must take the difference between Q_ϵ and the ideal state the system would be in had no measurement occurred; namely, $Z \otimes \mathbb{1}$. We define W_ϵ as

$$W_\epsilon = (U_1^\dagger (\mathbb{1} \otimes Z) U_1) - Z \otimes \mathbb{1}, \quad (13)$$

which is represented by

$$W_\epsilon = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & -2 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2 \end{pmatrix}.$$

This gives

$$W_\epsilon^2 = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 4 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 4 \end{pmatrix}. \quad (14)$$

Using our meter, we find the error in the operator Z ,

$$\epsilon^2(Z) = \langle \psi | W_\epsilon^2 | \psi \rangle \quad (15)$$

$$= 4 \sin^2 \theta. \quad (16)$$

which gives

$$\epsilon(Z) = 2 |\sin \theta| \quad (17)$$

for the error of a Z measurement. To find the disturbance in X , $\eta(X)$, we follow a similar procedure, again using the U_1 CNOT gate as the unitary transform, U , obtaining

$$\eta(X) = \langle (U_1^\dagger(X \otimes \mathbb{1})U_1 - X \otimes \mathbb{1})^2 \rangle^{\frac{1}{2}}.$$

Using the meter, we find

$$\eta(X) = \sqrt{2}|\cos \theta - \sin \theta| \quad (18)$$

for the disturbance in X of a Z measurement.

Following this same idea, we generate Table 1 by alternating taking a measurement in Z and in X . Further details can be found in Collings [17]. Note that whenever making a measurement in X , we must use a different CNOT gate, namely U_2 for the unitary transform U .

TABLE 1: Error E and disturbance η for measurements using various unitary transforms

| Measurement | ϵ | η |
|-------------------|---------------------------------------|---------------------------------------|
| $U=U_1, A=Z, B=X$ | $2 \sin \theta $ | $\sqrt{2} \cos \theta - \sin \theta $ |
| $U=U_2, A=X, B=Z$ | $\sqrt{2} \cos \theta - \sin \theta $ | $2 \sin \theta $ |
| $U=U_1, A=Z, B=Z$ | $2 \sin \theta $ | 0 |
| $U=U_2, A=X, B=X$ | $2 \sin \theta $ | 0 |

θ varies between 0 and π

With these values of error and disturbance, we will see in Section IX how the Heisenberg Uncertainty is violated for all values of θ .

IX. DISCUSSION

Our weak measurement simulation illustrates how measurement uncertainty differs from preparation uncertainty. Table 2 compares the left-hand sides of the HUR and of the Ozawa relation. The key factors are the $|\sin \theta|$ and $|\cos \theta - \sin \theta|$ terms in the HUR. When θ is equal or near 0, $|\sin \theta| = 0$, thus the left-hand side of the HUR goes to 0. When θ is equal or near $\frac{\pi}{4}$, $|\cos \theta - \sin \theta| = 0$, thus the left-hand side of the HUR again goes to 0. In either case, the HUR inequality is violated. However, the Ozawa relation has both a $|\sin \theta|$ term and a $|\cos \theta - \sin \theta|$ term, preventing the left-hand side from going to 0 at either of these points.

TABLE 2: Left-hand side of various uncertainty relations for the various measurements

| $U \ A \ B$ | LHS of Eq. (7) | LHS of Eq. (8) |
|-------------|---|--|
| U_1, Z, X | $2\sqrt{2} \cos \theta - \sin \theta \sin \theta $ | $2\sqrt{2} \cos \theta - \sin \theta \sin \theta + \sqrt{2} \cos \theta - \sin \theta + 2 \sin \theta $ |
| U_2, X, Z | $2\sqrt{2} \cos \theta - \sin \theta \sin \theta $ | $2\sqrt{2} \cos \theta - \sin \theta \sin \theta + \sqrt{2} \cos \theta - \sin \theta + 2 \sin \theta $ |
| U_1, Z, Z | 0 | $2 \sin \theta $ |
| U_2, X, X | 0 | $\sqrt{2} \cos \theta - \sin \theta $ |

This additional term comes from Ozawa's inclusion of the preparation uncertainty in calculating the measurement uncertainty. Without this inclusion, the relation would be violated, just as the HUR is violated.

To capture the impact of measurement strength on measurement uncertainty, we graph the results of a measurement in x with disturbance in z using the original HUR, the Ozawa relation, and the Branciard relation in Fig. 5. When θ is zero, the measurement is entirely in the z direction, resulting in the weakest possible measurement. Since error $\varepsilon(x) \sim |\cos \theta - \sin \theta|$ (see Table I), this measurement produces a large value for error; however, since disturbance $\eta(z) \sim |\sin \theta|$, the measurement produces a zero value for $\eta(z)$. This results in an HUR value of zero. As θ increases, the measurement begins to vary between the z and x components, resulting in an increase of measurement strength and thus a decrease in error and an increase in disturbance. When θ reaches the maximum value at $\frac{\pi}{4}$ the measurement is a mix of up and down in z , resulting in a measurement entirely in x . This causes disturbance $\eta(z) \sim |\sin \theta|$ to be large but error $\varepsilon(x) \sim |\cos \theta - \sin \theta|$ goes to zero. Thus, the HUR value once again returns to zero. We see that, regardless of the weak measurement's strength, the HUR is violated by measurement uncertainty, although it is more violated around $\theta = 0$ and $\frac{\pi}{4}$. It is important to note that while both Ozawa's and Branciard's relations

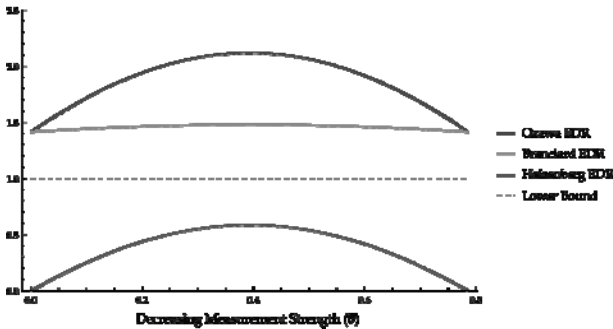


FIG. 5: Weak measurement simulation. By varying the strength of the measurement, we obtain the following error-disturbance relation (EDR) limits. When θ is zero, the measurement is fully in the Z direction. When θ is equal to $\frac{\pi}{4}$, the measurement is a mix of up and down in Z , which results in an measurement entirely in X .

hold, Branciard's relation is tighter. Our results clearly indicate a need to redefine uncertainty in regards to quantum measurements. More specifically, we must concur on a valid reformulation for measurement uncertainty, as the current HUR falls short when used for sophisticated measurement techniques.

A large part of the discussion confronting a reformulation of the HUR relies on semantics. Some [13] refer to Heisenberg's original words to defend the HUR, in contrast to the work examined here. They argue that the wording Heisenberg used makes the measurements done by Ozawa, Branciard, Erhart et al., and others, a moot point, stating that these contributions aren't examining what Heisenberg originally intended. Whether this is the case or not, our results show that the original HUR falls short when applied to particular measurement techniques. An argument as to what Heisenberg exactly meant is irrelevant when confronting the HUR with the experimental data that violate it. What is needed is clarity in the definition of the term uncertainty and universality in its applicability to all measurement techniques. It is not the first, nor likely the last time that a founding scientific principle should be revised.

X. THE HUR IN YEARS TO COME

We have presented a refinement of the definition of uncertainty, distinguishing preparation uncertainty from measurement uncertainty. The preparation uncertainty obeys the original HUR in regard to the uncertainty inherent in the preparation of a quantum system. It has been experimentally verified and has never been violated. It follows directly from sound mathematical derivation, going back to Heisenberg himself. We have no need to revise the HUR in regards to preparation uncertainty. Indeed, it may very well be said that the HUR is preparation uncertainty, for it is exactly what Heisenberg calculated in his original paper. Measurement uncertainty, on the other hand, requires a new definition to be universally valid, including for all currently available quantum measurement technique. Branciard's relation is the tightest relation we have today. Unlike the HUR, it provides meaningful and experimentally validated error and disturbance relations to weak and triple-state measurement experiments. It may seem unlikely that future progress in quantum measurement technique might in turn challenge Branciard's relation, given that it already incorporates the possibilities of vanishing error and vanishing disturbance; however, as we have learned after almost one hundred years of uncertainty awareness, the conceptual question that

Heisenberg introduced is a tricky one, unlikely to be settled once and for all.

References

- [1] W. Heisenberg, *Zeitschr. Phys.* **43**, 172 (1927).
- [2] J. S. Townsend, *A Modern Approach to Quantum Mechanics*, 2nd ed. (University Science Books, 2012).
- [3] O. Nairz, M. Arndt, and A. Zeilinger, *Phys. Rev. A* **65**, 032109 (2002).
- [4] A. P. Lund and H. M. Wiseman, *New J. Phys.* **12**, 093011 (2010).
- [5] M. Ozawa, *Ann. Phys.* **311**, 350 (2004).
- [6] M. Ozawa, *Phys. Rev. A* **67**, 042105 (2003).
- [7] J. Erhart, S. Sponar, G. Sulyok, G. Badurek, M. Ozawa, and Y. Hasegawa, *Nat. Phys.* **8**, 185 (2012).
- [8] L. A. Rozema, A. Darabi, D. H. Mahler, A. Hayat, Y. Soudagar, and A. M. Steinberg, *Phys. Rev. Lett.* **109**, 100404 (2012).
- [9] F. Kaneda, S.-Y. Baek, M. Ozawa, and K. Edamatsu, *Phys. Rev. Lett.* **112**, 020402 (2014).
- [10] J. Distler and S. Paban, *Phys. Rev. A* **87**, 062112 (2013), arXiv:1211.4169 [quant-ph].
- [11] A. Di Lorenzo, *Phys. Rev. Lett.* **110**, 120403 (2013).
- [12] C. Branciard, *Proc. Natl. Acad. Sci. U.S.A.* **110**, 6742 (2013).
- [13] P. Busch, P. Lahti, and R. F. Werner, *Phys. Rev. Lett.* **111**, 160405 (2013).
- [14] M. Ringbauer, D. N. Biggerstaff, M. A. Broome, A. Fedrizzi, C. Branciard, and A. G. White, *Phys. Rev. Lett.* **112**, 020401 (2014).
- [15] H. P. Robertson, *Phys. Rev.* **34**, 163 (1929).

[16] D. H. McIntyre, Quantum Mechanics: A Paradigms Approach (Pearson, 2012).

[17] J. “J” Collings, Quantifying the Uncertainty of the Heisenberg Uncertainty Relation: Preparation vs. Measurement Uncertainty, Bachelor’s Thesis, Brigham Young University, Provo, Utah (2015).

Determining Thin-Film Roughness with Extreme Ultraviolet Reflection

Cody L. Petrie, Joshua Marx, David Squires, and
R. Steven Turley

Brigham Young University

Abstract

We measured non-specular scattering of extreme ultraviolet light from thin films of UO_x (uranium oxide) on a SiO_2/Si substrate to determine the surface roughness of the thin film. The scattering data were compared with geometrical and physical optics calculations to respectively fit long wavelength and shorter wavelength features in model surfaces. The measurements were made on two thin films, one with a thickness of 44 nm and another with a thickness of 412 nm. Our models could not effectively fit the high-frequency roughness of the 44-nm film, but we were able to resolve characteristic low-frequency features. The root-mean-square roughness of the 412-nm film was 0.78 ± 0.15 nm assuming a Gaussian spatial frequency distribution with a standard deviation of $8.3 \times 10^{-5} \text{ nm}^{-1}$. Although the models only provided rough agreement with atomic force microscopy measurements, they demonstrate the utility of using optical methods to determine roughness in regimes where physical surface measurements are inaccurate or impractical.

1. Introduction

Extreme ultraviolet (EUV) light is a useful tool in many areas of science and technology. Its wavelength is on the order of 1–100 nm. As a result of its short wavelength, EUV light scatters more from surfaces with roughness having characteristic length scales on the order of nanometers than would visible light. To accurately measure the optical properties of materials in the EUV, and thereby design good reflective optics, one needs to carefully account for the effects of roughness on reflection of EUV light.

Commonly used physical measurements of surface roughness can be made using atomic force microscopy or electron microscopy. As discussed below, atomic force microscopy suffers from limited resolution at the shortest spatial frequencies, which are important to characterize EUV reflection attenuation. Transmission electron microscopy (TEM) measurements require challenging sample preparation that often obscures the features being probed. Scanning electron microscopes (SEMs) require less sample preparation, but lack the resolution of TEMs. Because of these challenges, we investigated an optical technique for measuring surface roughness. Since we are using the same probe we want to monitor, it is by definition, sensitive to the same spatial frequencies we are interested in. In contrast to TEM measurements, these measurements can be performed on the optical elements without destroying the elements themselves.

To be fair, we are comparing data from benchtop instruments like atomic force microscopes (AFMs) and SEMs with data gathered at the building-sized Advanced Light Source (ALS) at the Lawrence Berkeley National Laboratory in Berkeley, California. It should be noted, however, that EUV sources sufficient for the types of measurements considered here can also be made with plasma sources in benchtop systems such as the one described by Mitchell and Turley [1].

To effectively quantify the effects of surface roughness for a large class of surfaces, it is helpful to be able to parameterize a surface in terms of a few parameters. In previous work in our group, we determined that a surface with random amplitudes in the spatial frequency domain inside a Gaussian envelope is a good description of the surfaces of our sputtered thin films. We therefore decided to model our surfaces in terms of two parameters: the root-mean-square (rms) surface height and the width of this Gaussian envelope as described later in this paper and by Rockwood [2].

Early efforts to account for EUV surface roughness such as the Debye-Waller [3] and Nevot-Croce [4] corrections assumed Gaussian random heights of the surface (at all spatial frequencies) and

characterized the surface by a single parameter, the rms surface height. The inadequacy of this approach for our surfaces is illustrated by the two surfaces in Figure 1.1, which have identical rms surface heights, but rather different spatial frequency distributions.

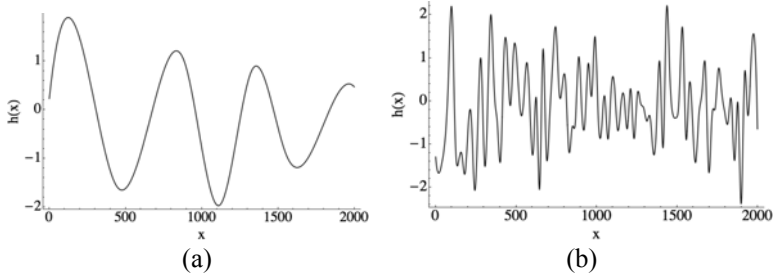


Figure 1.1: Two different surfaces. The surfaces have the same rms surface height but different spatial frequencies. Both axes are in units of wavelengths. The height of the surface in the vertical direction is labelled $h(x)$ and the distance along the axis as x . Note that the vertical scales are different in plots (a) and (b). Despite having the same rms height, these surfaces would reflect very differently.

Our calculations show that these two surfaces produce very different non-specular scattering patterns. This limitation was lifted by the later work of Sinha et al. [5], Stearns [6], and Gullikson et al. [7,8], who computed the effects of roughness accounting for different spatial frequency distributions. Their approaches invoke the first Born approximation, so they are only valid under conditions of weak reflection and do not take into account the polarization of the incident light.

Our approach is the first step to an analysis of non-specular reflection that is valid for stronger scattering and takes polarization effects into account. In this paper, we will do our analysis using the physical optics and geometrical optics approximations. In future work, we will compare the physical and geometrical optics calculations with the approach used by Hart and Turley [9], which more accurately handles the effects of high spatial frequencies.

1.1 Atomic Force Microscopy

Currently, one of the best ways to measure surface roughness is through atomic force microscopy. The AFM consists of a cantilever with a tip on one end. The tip is moved across the surface, and the tip

movements are measured by a laser that is reflected from the end of the cantilever as illustrated in Figure 1.2.

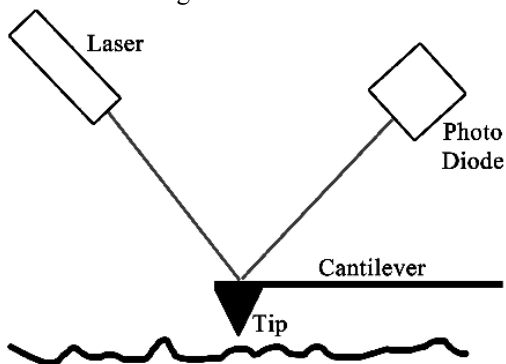


Figure 1.2: Schematic of an atomic force microscope.

As long as the tip is smaller than the roughness being measured this provides an accurate measurement of the roughness; however, if the roughness is on the order of 10 nm or smaller, like EUV wavelengths, an AFM tip may not be able to probe the roughness. This limitation is illustrated in Figure 1.3. Westra and Thomson [10] discussed the effect of AFM tip size on roughness measurements.

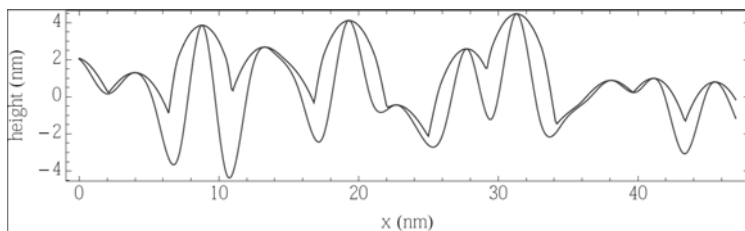


Figure 1.3: The bottom line is a modeled surface that has rms roughness of 1.85 nm. The top line is the height that would be measured by a parabolic AFM tip of size 3 nm. It would have a measured rms roughness of 0.70 nm.

The effect of a non-zero AFM tip size is to effectively filter out the highest spatial frequency components of the surface height. For this reason, our optical technique, which we have tested down to wavelengths as short as 1 nm, can provide a more sensitive measure of the surface features with characteristic sizes smaller than the AFM tip size.

1.2 Our Technique

Our technique for measuring surface roughness consists of comparing reflection measurements with reflection calculations from model surfaces with known roughness. The roughness parameters of the model surfaces are varied until the calculated reflection agrees with the measured reflection. Once they agree, we conclude that the real surface has the same roughness parameters as the model surface. Because our method uses EUV light, which can have wavelengths down to 1 nm, it is more sensitive to surface roughness on the order of a few nm.

The calculation that we are using for high-frequency surface features is a physical optics (PO) calculation. A similar analysis was done by Nethercott et al. [11] using a perfectly conducting surface. PO uses Maxwell's equations to calculate the radiated fields from a current on the surface. The currents are calculated using Fresnel reflection coefficients for the incident field. The Fresnel coefficients depend on whether the polarization is perpendicular to the plane defined by the incident and reflected waves (s polarization) or in that plane (p polarization). The Fresnel coefficients for reflection of s-polarized light r_s and the p-polarized light r_p are the ratio of the reflected field to the incident field.

$$r_s = \frac{n_1 \sin \theta_t - n_2 \sin \theta_i}{n_1 \sin \theta_t + n_2 \sin \theta_i} \quad (1)$$

$$r_p = \frac{n_1 \sin \theta_t - n_2 \sin \theta_i}{n_1 \sin \theta_t + n_2 \sin \theta_i} \quad (2)$$

In the above equations, n_1 is the index of refraction in the material of the incident light (1 in our case), n_2 is the index of refraction in the region of the transmitted light, θ_i is the angle the incident light makes with respect to the surface, and θ_t is the angle the transmitted light makes with respect to the surface. The geometry used to calculate the Fresnel coefficients is illustrated in Figure 1.4.

The physical optical calculation assumes that the current on the surface is that same as what one would get if the light were incident on a plane tangent to the surface at that point. In our case, the detector accepts virtually all of the light reflected in the azimuthal direction (out of plane) and has a narrow acceptance in the reflection plane. We therefore assume the surface is invariant in the azimuthal (z) direction.

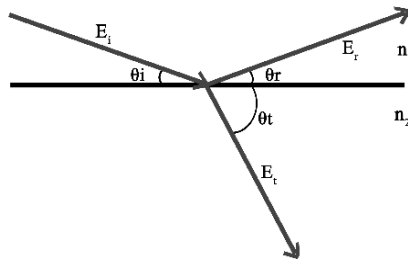


Figure 1.4: Illustration showing the geometry used to derive the Fresnel coefficients.

The result for the far field for reflection of s-polarized light, for example, is [12]

$$E_z^s = kg(\rho)e^{i3\pi/4} \int_S r_s \exp \{ i[kx'(\cos \theta_i - \cos \theta_r) - ky'(\sin \theta_i + \sin \theta_r)] \} \times \\ \left(\sin \theta_i + \frac{\sin \theta_r - \cos \theta_r \frac{dy'}{dx'}}{S} \right) dx'$$

where $k = \frac{2\pi}{\lambda}$ is the wave number, λ is the wavelength, $g(\rho) = \frac{e^{ik\rho}}{2\sqrt{2\pi k\rho}}$ is an outgoing cylindrical wave a distance ρ from the interface, and x' and y' are the coordinates along the surface of the interface.

The model surfaces used to compute the reflection were generated by creating an array of random heights with a Gaussian distribution. These were taken at equally-spaced x' points and then the Fourier transform was taken of this surface. The transformed surface was then multiplied by a Gaussian

$$G(x) = e^{-\frac{k_x^2}{2\sigma^2}}, \quad (4)$$

where σ is the width of the Gaussian (in the spatial frequency domain). The surface was then transformed back to real space. The rms height is then set by scaling each point on the surface to give the desired value. Once the surface is generated, reflection from the surface is calculated using Equation 3.

Figure 1.5 shows the progression from a random surface in real space to a filtered surface in inverse space and then a transformation back to real space again. Note how the transformation suppresses the highest frequency parts of the surface roughness, which would be unphysical at this length scale.

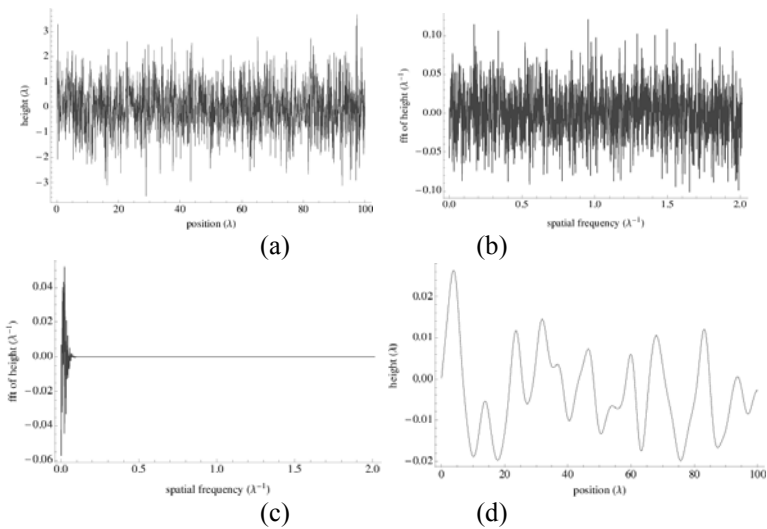


Figure 1.5: Graphs illustrating the process used to make our model surfaces. First, (a) random noise is generated, then the noise is transformed into frequency space (b). In frequency space the noise is filtered to remove the high-frequency components (c) and finally an inverse transform is performed to generate the final surface (d). Notice that the high spatial frequency components in (a) are removed in (d).

2. Methods

Reflection measurements were taken at the ALS. Measurements were taken on Beamline 6.3.2, which is dedicated to EUV reflectometer experiments. A diagram of the reflection chamber is shown in Figure 2.1.

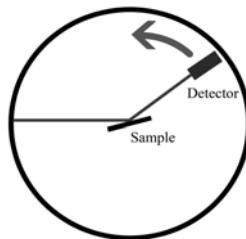


Figure 2.1: ALS vacuum chamber reflectometer. The sample and detector can be set at specified angles and then swept across different angles. In this paper, the angles of the sample and detector are measured relative to the direction of the incident beam.

The EUV beam enters the vacuum chamber on the left of the diagram and is then reflected from the sample. The wavelength can be set by different filters prior to the chamber to a precision of 0.007% with spectral purity of 99.98%. At our wavelengths, the polarization of the incident light was about 90% s (perpendicular to the plane of the incident and reflected beams). The incident angle can be changed by setting the angle of the sample stage, which has a 10- μm position precision in three dimensions. The angle can be set with 0.01° precision. The detector used for these measurements was limited to an angular acceptance of 0.17° in the plane of incidence and is much larger in the transverse direction. The detector is on an arm which can also be swept across different angles and can also be set with 0.01° precision. To gather reflection data the detector is set to an angle less than the peak reflection, which is twice the incident angle as measured from the incident beam. The detector is then moved toward the peak while collecting data with a channeltron detector. The channeltron detector detects single photons, but it may damage the detector to detect more than 10^6 photons. When we approached 10^6 photons, we added a filter to reduce the incoming photons and continued to scan toward the peak. In this manner, we were able to get reflection data over a range of nearly 10^8 on some measurements.

To piece together each measurement we scaled one of the scans by the ratio of the overlapping points to make a smooth transition between scans. Most of the scans only had one overlapping angle and so the ratio of reflections at that single angle was used to scale the scans so that they matched. When there was more than one point of overlap, however, an average ratio was used to scale the scans. In general, the variance in the scaling between multiple overlapping points was less than a few percent, giving confidence in the rescaling of reflectance with only one point of overlap. It did not matter whether scans were scaled up or down since the combined scan would be normalized later to match the calculated reflection.

PO calculations were then done on model surfaces with the same incident angle as each of the reflection measurements. To compare the calculations and measurements, the measured reflection profiles were normalized to have an integral of one over the range of comparison. We broke the reflected beam into two pieces: the narrow central specular peak and the broad background from non-specular scattering.

Figure 2.2 shows how the central peak of the calculated reflection converges on the measured reflection as the model surface is varied. This shows the process that was used to determine the roughness of thin films.

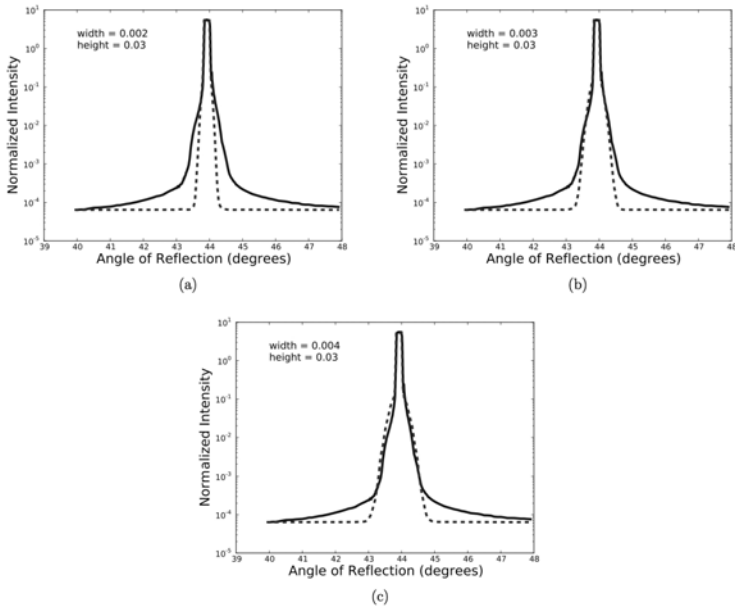


Figure 2.2: Each of these shows an attempt to fit the measured reflection (solid curve) with calculated reflection from a model surface (dashed curve). The curve in (a) has a model surface that is not rough enough. The curve in (b) shows a model surface that is a relatively good fit. The curve in (c) shows a model surface that is too rough. The spatial frequency of the model surface is increased from (a) to (c). The data in the example shown are for the sample with a 412-nm-thick film, a wavelength of 25 nm, and a 22° angle of incidence.

3. Analysis

AFM roughness measurements were taken for both samples. These were used to get some preliminary understanding of the surface roughness. Figure 3.1 shows the AFM data.

The AFM data show that the roughness of the sample with a 44-nm-thick film is greater than the roughness of the sample with a 412-nm-thick film. The AFM predicted rms roughnesses of 16.8 and 9.39 nm for the 44- and 412-nm samples, respectively. Also notice from the large scale bumps on the surface of the 44-nm sample in Figure 3.1a. The width of the bumps is on the order of a few hundred nm. This is much larger than the wavelength of EUV light.

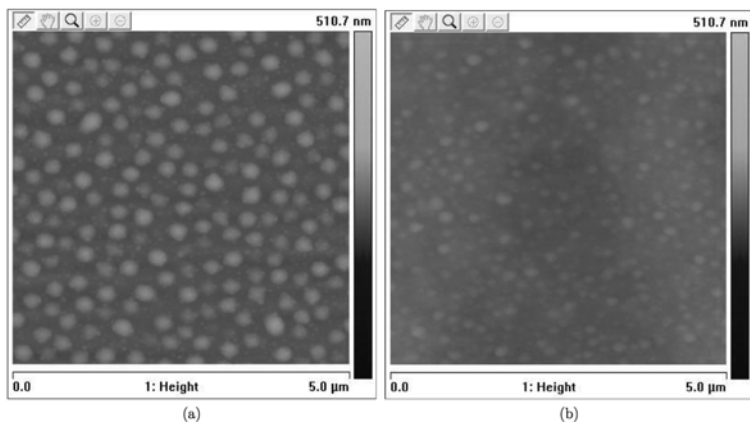


Figure 3.1: The AFM scans of the samples with a 44-nm-thick film (a) and a 412-nm-thick film (b). The lighter color corresponds to higher points on the surface.

Because of the difference in the nature of the surfaces from the two films, we used two different approaches to analyze the surfaces optically. The surface of the sample with the 412-nm film was relatively flat on the 5.0- μm scale of the AFM scan. Since the roughness had spatial frequency components close to the wavelength of the incident light, we analyzed that sample using a PO reflection model. The evident large-scale roughness on the sample with the 44-nm film prompted us to use geometrical optics to model the non-specular reflectance from that surface. This provided a compelling physical interpretation of the qualitative relationships between large-scale structure of the surface and the angular distributions of the reflected intensity.

The final measured and calculated reflection profiles for the 412-nm sample are shown in Figure 3.2. Note that four measurements were taken on each of the two samples with different incident angles and wavelengths of light. Because of the range of wavelengths each of these measurements has different sensitivity to the various spatial frequencies in the Fourier transform of the surface. Because the measurements are taken at different angles of incidence, the illuminated spot size along the plane of incidence is different in each case. For instance, a 200- μm spot perpendicular to the beam would illuminate a spot that was $\frac{200\mu\text{m}}{\sin(22^\circ)} = 894\mu\text{m}$ on the target for an angle of incidence of 22° as in Figure 3.2a. On the other hand, the same 200- μm beam would

illuminate a spot that was $\frac{200\mu\text{m}}{\sin(7^\circ)} = 1641\mu\text{m}$ on the target for an angle of incidence of 7° as is the case in Figure 3.2d. In addition, the filters used to attenuate the beams in the process described in Section 2 probably influenced the size of the beam as well as its intensity; each scanned section was probably averaging surface effects over different areas.

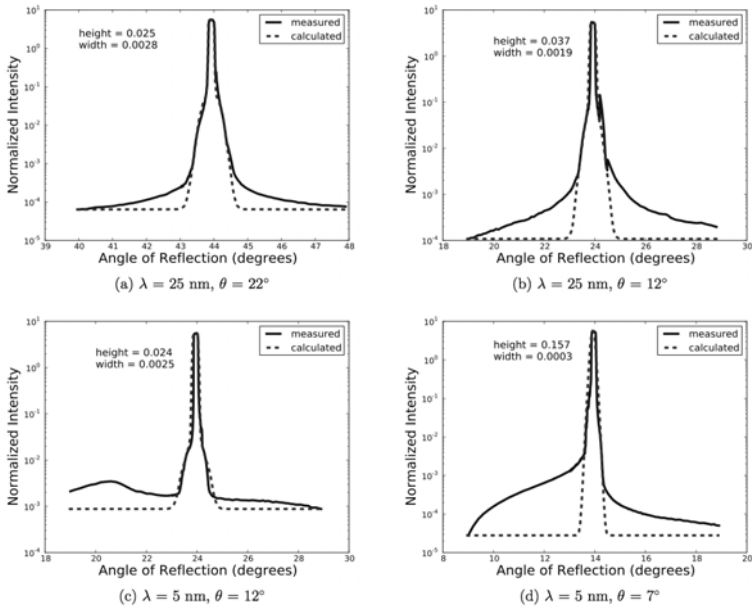


Figure 3.2: Fit of calculated reflection from model surfaces to the measured reflection profiles for the 412-nm sample. The height parameter is the rms height of the surface given in wavelengths. The width is the Gaussian cut-off frequency given in inverse wavelengths.

For the fitted measurements shown in Figure 3.2(a-d) the measured rms roughness heights were $0.12 \pm 0.015 \text{ nm}$, $0.625 \pm 0.05 \text{ nm}$, $0.925 \pm 0.175 \text{ nm}$, and $0.785 \pm 0.045 \text{ nm}$, respectively. The fitted widths to the Gaussian filters were $1.12 \times 10^{-4} \text{ nm}^{-1}$, $7.60 \times 10^{-5} \text{ nm}^{-1}$, $5.00 \times 10^{-4} \text{ nm}^{-1}$, and $6.00 \times 10^{-5} \text{ nm}^{-1}$, respectively. The distribution with a width $5.00 \times 10^{-4} \text{ nm}^{-1}$ is shown in Figure 3.3 as a characteristic power spectral density (PSD). Although the rms heights and widths were not all the same because of the effects noted in the previous paragraph, if the values from Figure 3.2 a, b, and d are averaged it provided a good fit for all three. This gave us an average rms height of $0.78 \pm 0.15 \text{ nm}$ and a Gaussian cutoff width of $8.3 \times 10^{-5} \text{ nm}^{-1}$.

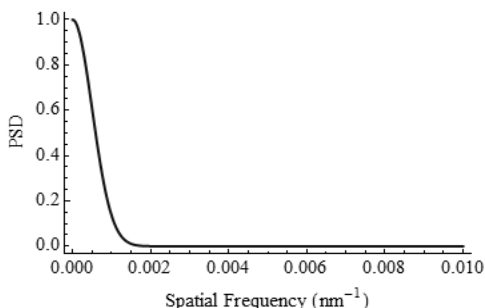


Figure 3.3: Power spectral density (PSD) of characteristic roughness spatial frequency. This plot was made from the sample with a 412-nm film used in Figure 3.2c. The Gaussian has a width of $5.00 \times 10^{-4} \text{ nm}^{-1}$ or 0.0025 inverse wavelengths.

Our model provided reasonable fits to the non-specular scattering for angles that differed from the spectral peak by a degree or less. Because of the highest spatial frequency components of the surface roughness, matching scattering at larger angles requires a surface model with more adjustable parameters than our chosen two-parameter Gaussians.

Note the significant difference between the rms surface roughness of the 412-nm film as measured by the AFM (9 nm) and these optical measurements (0.8 nm). Possible reasons for this discrepancy are discussed in Section 4.

We were not able to qualitatively match the measured reflection of the 44-nm sample to PO calculations. This was probably due to the large-scale (300-nm) bumps on the surface, which are not easily included in our chosen surface model. The measured reflection profiles for the 44-nm sample are shown in Figure 3.4.

The data from the 44-nm film can be understood qualitatively by modelling the pillow structures seen in Figure 3.1a as ellipsoidal bumps [13]. Using geometrical optics (which is appropriate for such large structures at these wavelengths), one can see that a structure with this shape would have a broad peak that rapidly drops to zero at a certain cut-off angle as shown in Figure 3.5. The central peak can be explained as before with a combination of specular reflection and smaller angle scattering from the higher spatial frequency components of the rough surface.

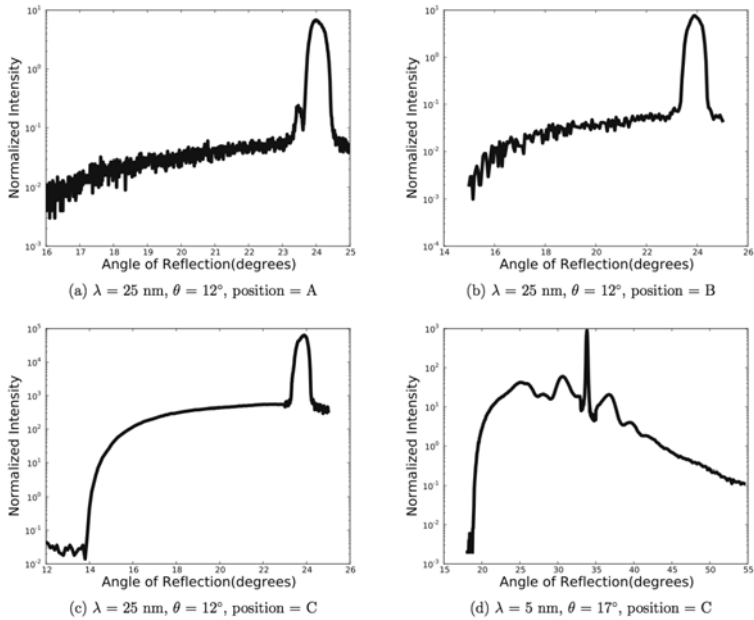


Figure 3.4: Reflection measurements taken from the 44-nm sample. These were done on different positions on the sample and with different wavelengths of light and incident angles. Positions A, B, and C correspond to rough, less rough, and smooth positions on the sample, respectively. Both the angle of the sample and the angle of reflection were measured relative to the direction of the incident beam. The plots are combined measurements from runs with different attenuation of the incident beam as required to stay within the operating range of the channel electron multiplier. The segments were normalized so that each section would correspond to an equivalent signal from the other sections having different attenuators.

The reflected light from the 44-nm film usually gave a symmetric pattern as shown in Figure 3.4a, b, and 5c. We surmise that the asymmetric pattern in Figure 3.4d is due to choosing a spot on the sample where the incident light hit a region with a part of a bump rather than a full bump or had some other artifact.

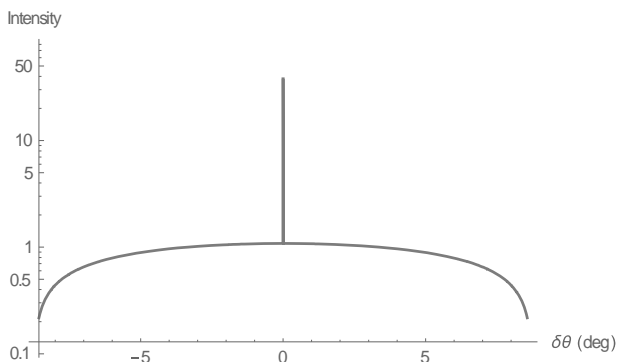


Figure 3.5 Geometrical optics calculation of reflection from a smooth surface with an elliptical pillow. The idealized surface for this model was an ellipse with a height of 10 nm and a width of 130 nm. The central sharp peak is from reflection from the flat surface away from the bump. The width of the broad peak and cut-off is determined by the geometry of the bump near its edges (assumed elliptical here). This simple surface model only included the bump and a smooth surface. Including high spatial frequency roughness on the surface would broaden out the central peak (as seen in the PO calculations) and roughen the shape of the broad peak (see Marx [13] for details). The horizontal axis on the plot is the deviation of the reflected light from the specular scattering angle measured in degrees. To compare this calculation with the graphs in Figure 3.4, twice the incident angle should be added to this scale in each case.

4. Conclusion

We have explored a method for determining the roughness of thin films using reflection of EUV light and reflection calculations from model surfaces. We have measured the reflection of two different UO_x thin films with thicknesses of 44 and 412 nm. We were unable to determine the roughness of the 44-nm sample, but we determined the roughness of the four measurements of the 412-nm sample to be 0.12 ± 0.015 nm, 0.625 ± 0.05 nm, 0.925 ± 0.175 nm, and 0.785 ± 0.045 nm, where the last three gave us an average rms height of 0.78 ± 0.15 nm. The AFM measured rms roughness of the 412-nm sample to be 9.39 nm, which is considerably different.

This discrepancy could be due to several factors including the insensitivity of AFM measurements to the highest frequency data, the angular resolution of our measurements, the approximations inherent in the PO calculation, an inadequate surface model, and the fact that our calculations averaged surface effects over a variety of surfaces whereas the measurement was at a particular point. We will discuss each of these separately.

As mentioned in Section 1.1, a primary motivation for this work was to find a way to measure the effects of surface roughness on optical reflectance at wavelengths shorter than the resolution of AFMs. Our optical results at the shortest wavelength of 5 nm included in this paper should be more sensitive to this high spatial frequency roughness than the AFM data. This is probably not the most significant contribution to the large discrepancy for the 412-nm film since it also appears in the 25-nm data where both techniques should have comparable spatial resolution.

The angular resolution of our measurement system would most significantly affect the lowest spatial frequency variations in our surface height. Neither our optical measurements nor our analysis would be as sensitive to these kinds of variations as a direct measurement of the surface height made by AFM. It is possible that our limited angular resolution underestimates the surface roughness because of this.

The approximations in the PO computation of surface reflectance may be the most significant source of discrepancy between the AFM and optical measurements. The AFM data indicate that there is important surface structure with characteristic length scales comparable with the wavelength of the light. This is the length scale where the approximations inherent in PO start to break down. Since the approximations are most valid in accounting for surface variations with low spatial frequencies, the failure of our model to account the large angle wings of the scattered light and relatively low width of the Gaussian filter cut-off in our surface models may be related to an inadequacy here.

It would be very helpful to compare these efficient, but approximate calculations to more accurate ones that avoid these approximations. We have developed the theory [14] and computer codes [9] to do this, but the large memory requirements have limited a direct comparison with these data so far.

Our model could be improved to fit the measured reflectance by using a boundary element model to more accurately calculate the effects of roughness at the highest spatial frequencies [9, 14]. The assumptions of physical optics introduce errors into the calculation when significant surface features have characteristic length scales about the wavelength of light. Both our reflectance data and the AFM measurements indicate that these corrections will be significant in our case.

Such calculations require significant computational resources for surfaces of our size. We have a program underway to compare non-specular reflection from model surfaces using PO and boundary

element methods to determine where these corrections are most significant.

We modelled the reflection from the 44-nm film with geometrical optics on a different surface model. The geometrical optical calculation did a good job relating the angular distribution of the reflected light to the shape and densities of the pillows seen in the AFM images of this film. The surface we used for geometrical optics did not include the high spatial frequency noise we used in the PO calculations. Based on the work on the 412-nm film, we would expect that including this noise in a refined calculation with a more complete surface model would resemble the surface shown in Figure 3.6 with a broadened central peak and a rougher structure in the broad wings. This would correspond nicely to the qualitative features in Figure 3.5.

Bibliography

[1] S. B. Mitchell, R. S. Turley, "Installation of a grazing incidence monochromator for use in the extreme ultraviolet," *J. Utah Acad. Sci. Arts Letts.* **84**, 154-160 (2008).

[2] A. Rockwood, Modeling Roughness Of A Sputtered Surface And Its Effects On Extreme Ultraviolet Reflection. Senior Thesis, Brigham Young University (April 2010).

[3] P. Debye, "Interferenz von Röntgenstrahlen und Wärmebewegung," *Annalen der Physik* **348**, 49-92 (1913).

[4] L. Nevot and P. Croce, Caractérisation des surfaces par réflexion rasante de rayons X. Application à l'étude du polissage de quelques verres silicates. *Rev. Phys. Appl.* **15**, 761 (1981).

[5] S. K. Sinha, E. B. Sirota, S. Garoff, H. B. Stanley, "X-ray and neutron scattering from rough surfaces," *Phys. Rev.* **B38**(4), 2297 (1988).

[6] D. G. Stearns, "The scattering of x rays from nonideal multilayer structures," *J. Appl. Phys.* **65**(2), 491-506 (1988).

[7] E. M. Gullikson, D. G. Stearns, D. P. Gains, J. H. Underwood, "Non-specular scattering from multilayer mirrors at normal incidence," *Proc. SPIE* **3133-55**, 412 (July, 1997).

- [8] E. M. Gullikson, "Scattering from normal incidence EUV optics," SPIE **3331**, 72-80 (1998).
- [9] G. R. Hart, R. S. Turley, "The effect of surface roughness on reflected intensity," J. Utah Acad. Sci. Arts Letts. **90**, 169-180 (2012)
- [10] K. L. Westra, D. J. Thomson, "Effect of tip shape on surface roughness measurements from atomic force microscopy images of thin films," J. Vac. Sci. Technol. B **13**, 344 (1995).
- [11] Q. Nethercott, C. L. Petrie, and R. S. Turley, "Non-specular reflectance in the extreme ultraviolet," J. Utah Acad. Sci. Arts Letts. **89**, 181-193 (2012).
- [12] R. S. Turley, "Physical Optics," BYU Internal Report (2013).
- [13] J. Marx, "Determining surface roughness using extreme ultraviolet light," Senior Thesis, Brigham Young University (April 2014).
- [14] J. E. J. Johnson, Computationally Modeling the Effects of Surface Roughness on Soft X-Ray Multilayer Reflectors. Master's Thesis, Brigham Young University (2006).

Phosphatidylserine–Copper (II) Binding Can Lead to Fast Through-Membrane Copper Transport

Michael J. Trujillo, D. Tyler Scholes,
Christopher M. Reynolds, Conner Winegar, and
Christopher F. Monson

Southern Utah University

Abstract

Phospholipid bilayers are crucial parts of cells and a topic of importance in chemistry, biology, and medicine. Phosphatidylserine (PS) is a phospholipid that is known to bind copper (II) ions with high affinity. Copper (II) was observed to enter lipid vesicles and catalyze the formation of a colored product only when PS was present. Additionally, EDTA was shown to strip copper from supported lipid bilayers to an extent equal to making the solution over the bilayer acidic. Together, these results demonstrate that the phosphatidylserine–copper complex allows the copper to move across the membrane. The surprising observation that an ion can travel through a bilayer without the assistance of protein channels has significant implications for biological transport and may be relevant to some diseases as well.

Introduction

An integral part of cell membranes, phospholipids consist of a hydrophilic (water-loving) head group and hydrophobic (water-fearing) tails. In cell membranes, this structure causes them to arrange themselves in a bilayer pattern wherein hydrophilic heads face out toward aqueous solution both on the outside of the cell and on the inside of the cell (the cytoplasm).¹ The hydrophobic tails are sequestered in a thin layer between the lipid heads, acting as an oily barrier to the transport of material into or out of a cell. This barrier is crucial for life—without the membrane cells would not be able to maintain sufficiently high concentrations of biomolecules to sustain life. This bilayer structure occurs spontaneously when phospholipids are introduced into an aqueous environment, with lipids commonly aggregating into hollow, roughly spherical bilayer structures known as vesicles. While there is a significant body of work on the behavior, properties, and uses of lipids in vesicles, vesicles can also be used to form a supported lipid bilayer (SLB).^{2,3} SLBs form when small vesicles (<200-nm diameter) encounter a very clean, smooth glass (or quartz or mica) surface. Upon encountering the surface, the vesicles flatten and rupture, forming a two-dimensional lipid sheet a few nanometers above the surface of the support.⁴ SLBs have been used by many researchers to investigate the properties of lipids and as model cell membranes.⁵⁻¹⁸ One lipid that has been investigated by a number of different researchers is phosphatidylserine (PS).¹⁹⁻³⁴

PS, like all phospholipids, consists of two hydrophobic tails bound to a polar head group. The head group of PS consists of the amino acid serine, with the alcohol group on the serine side chain attached to the phosphate of the lipid head. Thus, an amine group and a carboxylic acid group are both exposed to the aqueous solution in PS. PS is found in many different organisms, but in eukaryotes is relatively unique in its asymmetric distribution in cell membranes. PS occurs almost exclusively on the inside leaflet (or the inside layer of lipids in the lipid bilayer) of cell membranes, and this distribution is maintained by a membrane protein called flippase, which flips any PS on the outer leaflet to the inner leaflet.¹⁹ The maintenance of this distribution is essential for cell survival, as PS on the outer leaflet is a marker of cell apoptosis (controlled cell death) and leads to the destruction of the cell by macrophages.²⁴ PS is involved in a number of interactions other than those leading to the apoptotic destruction of the cell, including the relatively recently discovered high binding affinity for copper (II) ions. This interaction is particularly interesting, as copper (II) quenches fluorophores, and thus the copper–PS interaction can be easily

measured with fluorescence.³⁴ In addition to binding copper (II), there is circumstantial evidence that PS can transport copper (II) from one bilayer leaflet to another, presumably in a PS–copper complex. This evidence can be summarized by the results of a few titration experiments, in which copper added to a solution of preformed PS vesicles resulted in the quenching of virtually all the fluorophores in the vesicle (both those on the inner membrane leaflet and those on the outer leaflet), despite the short range of quenching of the copper–PS complex. In this paper, we report our work on this potential copper–PS interaction and transport using both vesicle techniques and SLB techniques.

Experimental Methods

Lipid Vesicle Formation

Lipid vesicles were formed as described in the literature,³⁴ with one minor difference. Briefly, known amounts of the desired lipids (1-palmitoyl-2-oleoyl-*sn*-glycero-3-phosphocholine, PC, and 1,2-dioleoyl-*sn*-glycero-3-phospho-L-serine, PS, 1–25 mg aliquots purchased from Avanti) were dissolved in chloroform and mixed to form the desired mole ratios (0.5–25 mole % PS). The chloroform was evaporated by a stream of air until visibly dry and then in a vacuum for 2–4 hours. The dried lipid mixture was rehydrated with 1.0 mL of a buffer (usually 0.01 M Tris(hydroxymethyl)-aminomethane, Fisher, 0.1 M NaCl, pH 7.4, Tris) while vigorously swirling the solution. This typically eliminated the need to subject the lipid solution to freeze-thaw cycles, allowing the lipid vesicles to be extruded directly with a mini-extruder using a 100-nm-pore polycarbonate membrane (Avanti; a minimum of 10 extrusions were performed) and then diluted to a final concentration of 1 mg/mL with Tris buffer. This resulted in lipid vesicles with a diameter of approximately 100 nm.

Orcinol Experiment

To directly measure the migration of copper ions through a lipid bilayer, a series of vesicle experiments were performed using orcinol (Fisher). Orcinol is a small organic molecule that is water-soluble and undergoes a reaction to form a reddish compound in the presence of copper.³⁵ The reactivity of copper and orcinol was first tested in a series of conditions ranging from 1 to 0.1 M orcinol and 0 to 8.6×10^{-4} M copper (II) sulfate (Fisher) in Tris buffer. The reaction was monitored both visually and by UV-Vis over the course of several weeks. On the

basis of the results of this experiment, vesicles were created as described above with an aqueous solution containing both Tris buffer and 0.1 M orcinol. The vesicles used were in two batches: in one batch the vesicles were made solely of PC, and the other batch was a mix of 90 mole % PC with 10 mole % PS. For both types of vesicles, orcinol was initially present in the interior and exterior aqueous portions of the vesicle. This allowed the orcinol outside of the vesicles to be removed, while the orcinol inside the vesicles was unable to escape as the vesicle was too large to travel through the pores in the dialysis tubing. The vesicles were dialyzed over 2 weeks at 4°C using dialysis tubing with a cutoff of 12000 Da with five solution exchanges to remove the orcinol outside the vesicles. The vesicles were then transferred to cuvettes and a Tris buffer solution containing 8 μM copper (II) sulfate was added, for a final copper (II) concentration of around 7 μM . The absorbance of the vesicle solutions was monitored at 480 nm using UV-Vis over the course of 12 days.

Glass Cleaning

For experiments involving SLBs, cleaned and annealed glass slides were required. Glass coverslips (Fisher, 25×25 mm, No. 1) were cleaned in boiling 7x solution (MP Biomedical) diluted approximately 1:10 with deionized water for 30 min. The cover slips were rinsed thoroughly with deionized water after cleaning and blown dry with air. The slides were annealed on a ceramic rack at 530°C overnight.

SLB Experiment

A device was created that consisted of two channels in a sheet of polydimethylsiloxane (PDMS, a clear elastomer) to measure the fluorescence of a bilayer containing PS and a bilayer without any PS while solutions above the bilayers were being changed. The PDMS sheet was held between two glass slides. The glass slides enclosed the channels and supported the bilayer. At their nearest point, the two channels were approximately 1 mm apart, which allowed the bilayer in both channels to be imaged simultaneously and compared under identical lighting conditions, which can otherwise lower the reproducibility of fluorescence measurements. In one of the channels, 50 μL of vesicles containing 10 mole % PS, 0.5 mole % Texas Red-labeled lipid (Texas Red 1,2-Dihexadecanoyl-*sn*-Glycero-3-Phosphoethanolamine, Life Technologies, Texas Red PE), and 89.5 mole % PC were added to the channel, while the other (control) channel had 0.5 mole % Texas Red-labeled lipid and 99.5 mole % PC. One lipid solution was added to each channel and SLBs were allowed

to form for 30 minutes, after which the excess lipid vesicles were rinsed away by flowing deionized water through the channels.

The experiments were performed by flowing a series of solutions through both channels simultaneously. Typically, a pH 8 Tris buffer solution containing 0.1 mM copper (II) sulfate was flowed through the channel for approximately five minutes until the fluorescence in the PS-containing channel was observed to reach a minimum as the 1,2-dioleoyl-*sn*-glycero-3-phospho-L-serine (DOPS)-bound copper and the fluorophores were quenched. A pH 3.5 solution (citric acid buffer, 0.01 M total citrate and 0.1 M NaCl) was then flowed through the channels for a few minutes until the fluorescence in the PS channel reached a maximum. The initial (basic, copper-containing) solution was flowed through the device until the fluorescence returned to its low value, and then a pH 8 Tris buffer solution with 1 mM EDTA was added. The bilayers were then typically cycled between the pH 8 Tris buffer with 0.1 mM copper (II) sulfate solution and the Tris and EDTA solution for the remainder of the experimental run, with one more acid run on long experimental runs to verify bilayer behavior. During each step of the process, the fluorescence was monitored at known intervals (every 30 s is shown in Figure 4 (below); runs were also performed with images taken every 10 s) so that the kinetics of the binding and unbinding process could be measured and compared.

Results and Discussion

Orcinol Experiment

We initially measured the reactivity of copper and orcinol in Tris buffer to establish the conditions to use in vesicle experiments. As can be seen in Figure 1, the orcinol reaction is catalyzed by copper as reported in the literature, but also takes place at high orcinol concentrations in the absence of copper. While Figure 1 shows the progress of the reaction after one week, the reaction was monitored for two more weeks. During this time, the reactions slowly continued, with the colored wells gradually growing darker and the 0.1 M orcinol and no copper well remaining relatively clear. For our experiments, a long preparation period was inevitable, as the orcinol outside the vesicles had to be removed by dialysis, which is an inherently slow process. Therefore, we used 0.1 M orcinol in our vesicle solution, as this exhibited almost no reactivity in the absence of copper, even though the color produced in the orcinol reaction was less easily detected.

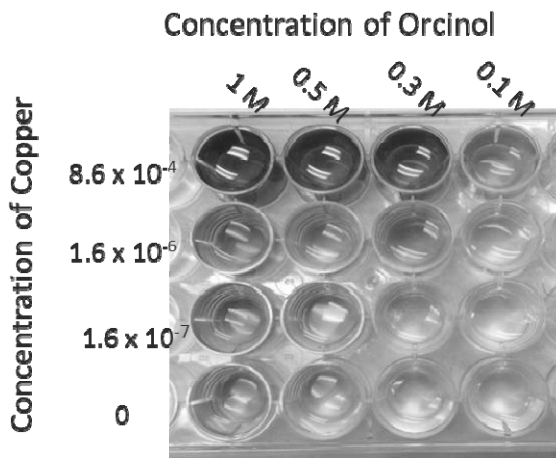


Figure 1. Orcinol reactivity in Tris as a function of copper concentration after one week. The darker the color, the more extensive the reaction.

Vesicle solutions were prepared as described above to measure the transport of copper. The idea behind these experiments was simple and is illustrated in the upper portion of Figure 2. The orcinol, which had initially been in solution both inside and outside the vesicles, had been removed from the solution outside the vesicle by the dialysis. Thus, the orcinol–copper reaction could only happen if copper got into the vesicles (or orcinol got out). This was prevented by the vesicles themselves, which are typically impermeable to charged and polar compounds (such as copper and orcinol). Therefore, the only way the reaction could take place was if either the copper was transported into the vesicle or the orcinol was transported out. The control PC vesicles served to determine the extent of the reaction that took place because of orcinol transport, as it should be similar in both PC and PS/PC vesicles. On the other hand, if the copper–PS interaction allowed the transport of copper across the lipid membrane, then a significant amount of copper should be transported into the vesicles containing PS, leading to a reaction within the vesicles. To determine whether this reaction was in fact occurring, UV-Vis measurements of both the PC and the PS/PC vesicles were taken every day following the addition of copper to a final copper concentration of around $10 \mu\text{M}$. This relatively low

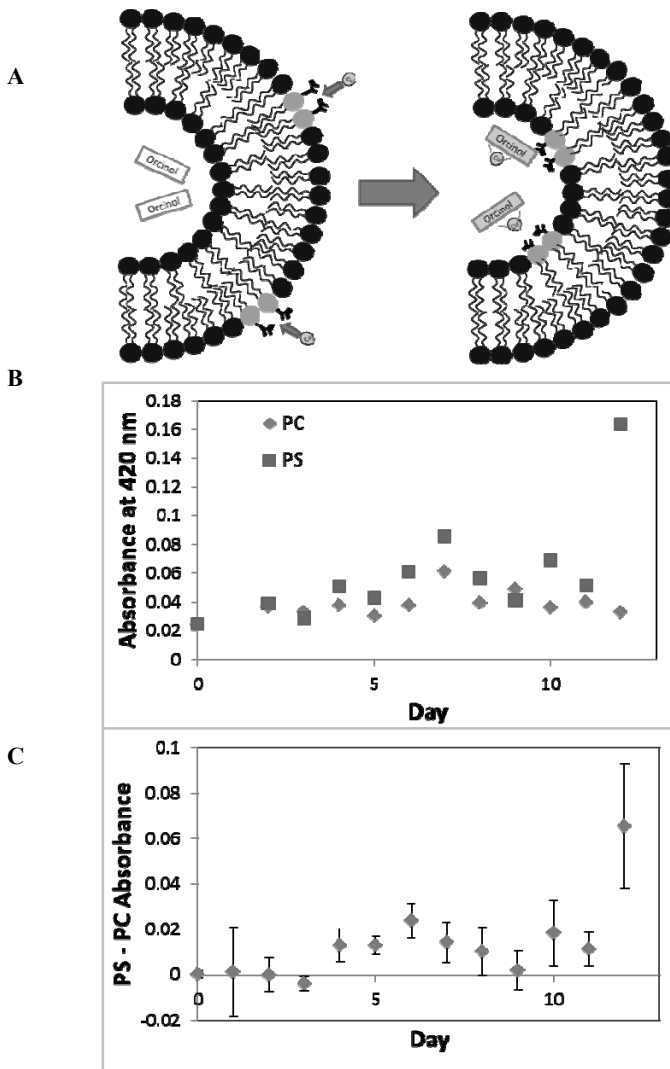


Figure 2. Representation of orcinol reaction inside vesicles (A) and UV-Vis absorbance data (B,C). (B) Graph showing the extent of these reactions when a vesicle contains only PC (diamonds) or 10 mole % PS in PC (squares). (C) Graph showing the average excess PS absorbance (PS absorbance minus PC absorbance) with error bars reflecting standard deviations between measurements.

number was chosen to avoid vesicle rupture due to ionic strength imbalance between the inside and the outside of the vesicle. The absorbance at 480 nm (previously determined to be the maximum for the orcinol reaction products) was measured for both the vesicles containing PS and those with only PC. The results of these measurements are shown in Figure 2. As can be seen, for about a week the two solutions exhibited no significant, lasting difference; however, after a week the PS-containing vesicles began to show increased absorbance, indicating an orcinol reaction. This continued for several days until both vesicles showed a sharp increase in absorbance after 12 days. We attribute this to vesicle rupture due to ionic strength differences between the interior and exterior of the vesicle following the gradual evaporation of the solution. This evaporation tends to increase the ionic strength outside of the vesicle until the vesicles rupture and allows the orcinol-copper reaction to happen in both PS- and PC-containing vesicles alike. The increase in the absorption after a week in the PS-containing vesicles suggests that some transport phenomenon was occurring in these vesicles, either orcinol out or copper in. As there is no reason to expect an orcinol-PS interaction leading to the transport of orcinol and PC is present in both sets of vesicles, the best explanation for this increase is that the copper was transported into the vesicles by a copper-PS interaction. However, this reaction does not say anything about the timescale of the copper-PS interaction, as the orcinol-copper reaction had previously been demonstrated to be slow, taking several days to several weeks to show an appreciable reaction, particularly at low orcinol and copper concentrations.

SLB Experiment

To verify the results from the vesicle experiments and get an idea of the timescale of the PS-mediated copper transport, additional experiments were performed with a SLB in a two-channel flow device. In this device, the copper-PS interaction was monitored by means of fluorescence. Copper (II) is known to quench a wide range of fluorophores. When PS binds to the copper (II), the copper-PS complex quenches lipid-bound fluorophores (Figure 3A), but this interaction has been shown to be short-ranged; for example, the copper-PS complex is unable to significantly quench fluorophores bound to membrane-associated proteins.³⁴ Thus it is expected that, if the copper-PS complex formation occurred asymmetrically (more extensively on one leaflet than the other), the quenching would also be

asymmetric, with greater quenching occurring on whatever leaflet exhibited greater complex formation.

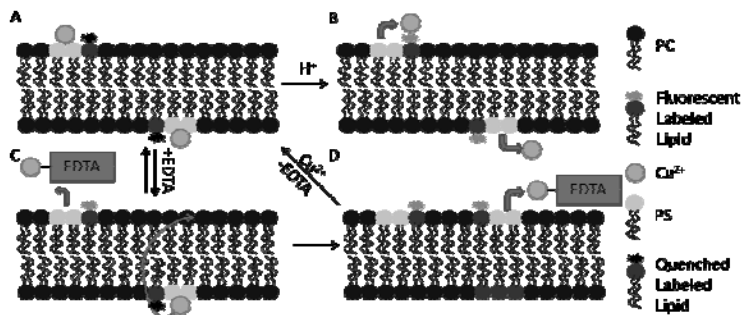


Figure 3. Fluorescent quenching and Cu–PS binding behavior under the experimental conditions tested. (A) Under basic conditions, PS (light gray) binds copper and quenches fluorescently labeled lipids (black). (B) Under acidic conditions, the copper is released from the PS and the labeled lipid fluoresces (dark gray). (C) When EDTA is added to lipid in basic conditions, the EDTA competitively binds to the copper ions on the upper leaflet, removing them. (D) Any Cu–PS complexes on the lower leaflet then flip to the upper leaflet and the copper is removed by the EDTA.

Contrary to the simple model outlined above, when the copper–PS complex is formed asymmetrically, it has been shown to quench essentially all fluorophores (on both leaflets), whether in vesicle or supported lipid bilayer form (Figure 3B).³⁴ This supports the copper–PS transport hypothesis, but the changes in ionic strength and/or pH inherent in many of these methods implies that the observed complete quenching could be due to vesicle/SLB rupture, as indeed was observed at the end of our vesicle experiments. In the SLB experiments, we first measured the quenching due to the copper–PS complex under both acidic (pH 3.5) and basic (pH 8, 0.1 mM copper) conditions as can be seen in Figure 4. To reduce interference due to changes in lamp intensity or background lighting, the fluorescence of a bilayer containing a Texas Red-PE/PS/PC mix and a bilayer containing just Texas Red-PE/PC were measured simultaneously in two channels. As has been observed before,³⁴ the basic conditions resulted in essentially complete quenching of the fluorophores. We then introduced 1 mM EDTA in solution otherwise identical to the basic solution just used (0.01 M Tris, 0.1 M NaCl, pH 8) but without the copper (II). As sodium chloride is present in 100-fold excess of the EDTA and the copper was removed, this should represent a very small change in ionic

strength and no significant change in pH. Thus, there should be no bilayer rupture and, in the absence of PS-mediated copper transport, the

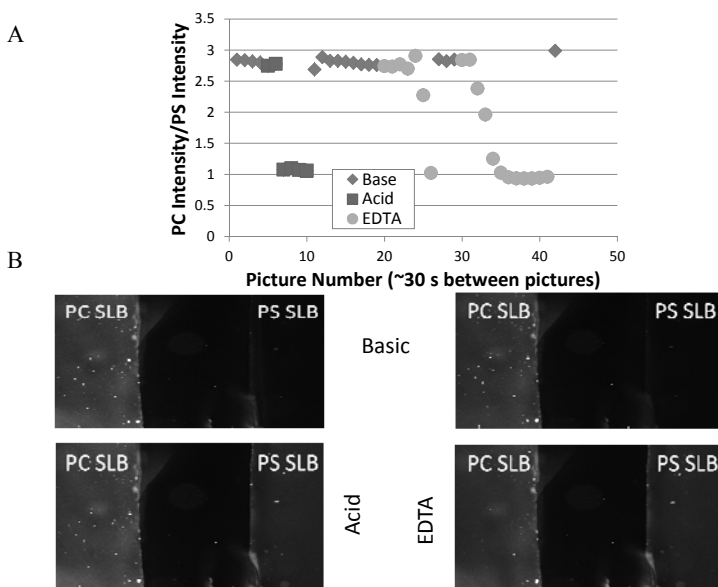


Figure 4. EDTA burst experimental results. (A) The ratio of the fluorescence of the channel with just PC to the fluorescence of the channel with both PS and PC is graphed as a function of time while the solution above the bilayer was changed. (B) Representative pictures of the fluorescence of the SLBs are shown after 30 s of treatment with the solution indicated in the center.

EDTA should only be able to strip the copper from the top leaflet of the bilayer and thus should be able to unquench only that fraction of the total fluorophores that are on the upper leaflet (Figure 3C). As can be seen in Figure 4, the fluorophores are unquenched to a degree essentially identical to the unquenching observed with acid, although the unquenching is somewhat slower—requiring about one minute, whereas the acidic quenching took place in under 30 seconds.

This strongly suggests that, first of all, copper–PS binding can result in the transport of copper across the bilayer (Figure 3D). Were this not the case, the unquenching with EDTA would have been significantly less extensive than that which occurred with acidic solutions. Second, this also gives a lower limit to the timescale at which copper–PS transport can occur. As the entire unquenching process occurred in about a minute, the majority of the copper must have been

transported from the lower leaflet to the upper leaflet in this period of time. This implies a very rapid transport rate indeed, particularly as, at least until recently,³⁶⁻³⁸ the timescale for lipid flip-flop was thought to be hours to days.

Conclusions

In this paper, two sets of experimental results are presented that support the hypothesis that when the copper–PS complex forms, the copper can be transported across the membrane. It was demonstrated that orcinol encapsulated in vesicles containing PS was able to react with copper. As orcinol in vesicles containing just PC did not react until the vesicles burst, this strongly supports the hypothesis that the copper–PS complex facilitates copper transport. In a second experiment, it was demonstrated that both acidic solutions and basic EDTA unquench fluorophores that have been quenched by the copper–PS complex and do so to the same degree. As there was almost no change in ionic strength or pH with the EDTA solution, this not only supports PS-mediated copper transport, but also sets a bound for the slowest rate at which such transport can occur. This rate is remarkably fast—on the order of seconds, rather than minutes to days that has been previously reported.

Acknowledgments

We thank Susan Harris for making the ceramic rack we used to anneal glass slides. We thank the SUU Faculty Scholarly Support Fund for funding this project. M.J.T. thanks the Walter Maxwell Gibson Summer Research Fellowship program for its support. C.M.R. thanks David and Jill Luttrell for their financial support.

References

1. Nelson, D.L.; Cox, M.M. *Lehninger Principles of Biochemistry*, 3rd ed.; Worth Publishers: New York, 2000; pp 363-430.
2. Brian, A.A.; McConnell, H.M. Allogeneic stimulation of cytotoxic T cells by supported planar membranes. *Proc. Natl. Acad. Sci. U.S.A.* **1984**, *81*, 6159-6163.
3. Tamm, L.K.; McConnell, H.M. Supported phospholipid bilayers. *Biophys. J.* **1985**, *47*, 105-113.

4. Hamai, C.; Cremer, P.S.; Musser, S.M. Single giant vesicle rupture events reveal multiple mechanisms of supported bilayer formation. *Biophys. J.* **2007**, *92*, 1988-1999.
5. Jönsson, P.; Beech, J.P.; Tegenfeldt, J.O.; Höök, F. Shear-driven motion of supported lipid bilayers in microfluidic channels. *J. Am. Chem. Soc.* **2009**, *131*, 5294.
6. Nabika, H.; Sasaki, A.; Takimoto, B.; Sawai, Y.; He, S.; Murakoshi, K. Controlling molecular diffusion in self-spreading lipid bilayer using periodic array of ultra-small metallic architecture on solid surface. *J. Am. Chem. Soc.* **2005**, *127*, 16786-16787.
7. Neumann, J.; Hennig, M.; Wixforth, A.; Manus, S.; Radler, J.O.; Schneider, M.F. Transport, separation, and accumulation of proteins on supported lipid bilayers. *Nano Lett.* **2010**, *10*, 2903-2908.
8. Nissen, J.; Gritsch, S.; Wiegand, G.; Radler, J.O. Wetting of phospholipid membranes on hydrophilic surfaces—Concepts towards self-healing membranes. *Eur. Phys. J. B.* **1999**, *10*, 335-344.
9. Stelzle, M.; Miehlich, R.; Sackmann, E. Two-dimensional microelectrophoresis in supported lipid bilayers. *Biophys. J.* **1992**, *63*, 1346-1354.
10. Daniel, S.; Diaz, A.J.; Martinez, K.M.; Bench, B.J.; Albertorio, F.; Cremer, P.S. Separation of membrane-bound compounds by solid-supported bilayer electrophoresis. *J. Am. Chem. Soc.* **2007**, *129*, 8072-8073.
11. Groves, J.T.; Boxer, S.G. Electric field-induced concentration gradients in planar supported bilayers. *Biophys. J.* **1995**, *69*, 1972-1975.
12. Groves, J.T.; Boxer, S.G.; McConnell, H.M. Electric field-induced reorganization of two-component supported bilayer membranes. *Proc. Natl. Acad. Sci. U.S.A.* **1997**, *94*, 13390-13395.
13. Groves, J.T.; Wulfing, C.; Boxer, S.G. Electrical manipulation of glycan-phosphatidyl inositol-tethered proteins in planar supported bilayers. *Biophys. J.* **1996**, *71*, 2716-2723.
14. Kam, L.; Boxer, S.G. Spatially selective manipulation of supported lipid bilayers by laminar flow: steps toward biomembrane

microfluidics. *Langmuir* **2003**, *19*, 1624-1631.

15. van Oudenaarden, A.; Boxer, S.G. Brownian ratchets: molecular separations in lipid bilayers supported on patterned arrays. *Science* **1999**, *285*, 1046-1048.

16. Yoshina-Ishii, C.; Boxer, S.G. Controlling two-dimensional tethered vesicle motion using an electric field: interplay of electrophoresis and electro-osmosis. *Langmuir* **2006**, *22*, 2384-2391.

17. Han, X.J.; Cheetham, M.R.; Sheikh, K.; Olmsted, P.D.; Bushby, R. J.; Evans, S.D. Manipulation and charge determination of proteins in photopatterned solid supported bilayers. *Integr. Biol.* **2009**, *1*, 205-211.

18. Monson, C.F.; Pace, H.; Liu, C.; Cremer, P.S. Supported bilayer electrophoresis under controlled buffer conditions. *Anal. Chem.* **2011**, *83*, 2090-2096.

19. Leventis, P.A.; Grinstein, S. The distribution and function of phosphatidylserine in cellular membranes. *Annu. Rev. Biophys.* **2010**, *39*, 407-427.

20. Gordesky, S.E.; Marinetti, G.V. The asymmetric arrangement of phospholipids in the human erythrocyte membrane. *Biochem. Biophys. Res. Commun.* **1973**, *50*, 1027-1031.

21. Zambrano, F.; Fleischer, S.; Fleischer, B. Lipid composition of the Golgi apparatus of rat kidney and liver in comparison with other subcellular organelles. *Biochim. Biophys. Acta* **1975**, *380*, 357-369.

22. Tyurina, Y.Y.; Shvedova, A.A.; Kawai, K.; Tyurin, V.A.; Kommineni, C.; Quinn, P.J.; Schor, N.F.; Fabisiak, J.P.; Kagan, V.E. Phospholipid signaling in apoptosis: peroxidation and externalization of phosphatidylserine. *Toxicology* **2000**, *148*, 93-101.

23. Majd, S.; Estes, D.J.; Mayer, M. Assays for studying annexin binding to artificial bilayers. *Calcium Binding Proteins* **2006**, *1*, 26-29.

24. Bailey, R.W.; Nguyen, T.; Robertson, L.; Gibbons, E.; Nelson, J.; Christensen, R.E.; Bell, J.P.; Judd, A.M.; Bell, J.D. Sequence of physical changes to the cell membrane during glucocorticoid-induced apoptosis in S49 lymphoma cells. *Biophys. J.* **2009**, *96*, 2709-2718.

25. Chaurio, R.A.; Janko, C.; Munoz, L.E.; Frey, B.; Herrmann, M.; Gaipf, U.S. Phospholipids: key players in apoptosis and immune regulation. *Molecules* **2009**, *14*, 4892-4914.
26. Lentz, B. Exposure of platelet membrane phosphatidylserine regulates blood coagulation. *Prog. Lipid Res.* **2003**, *42*, 423-438.
27. Huang, B.X.; Akbar, M.; Kevala, K.; Kim, H.Y. Phosphatidylserine is a critical modulator for Akt activation. *J. Cell Biol.* **2011**, *192*, 979-992.
28. Hauser, H.; Darke, A.; Phillips, M.C. Ion-binding to phospholipids: interaction of calcium with phosphatidylserine. *Eur. J. Biochem.* **1976**, *62*, 335-344.
29. Papahadjopoulos, D.; Poste, G. Calcium-induced phase separation and fusion in phospholipid membranes. *Biophys. J.* **1975**, *15*, 9445-948.
30. Feigenson, G.W. On the nature of calcium ion binding between phosphatidylserine lamellae. *Biochemistry* **1986**, *25*, 5819-5825.
31. Tokutomi, S.; Lew, R.; Ohnishi, S.-I. Ca^{2+} -induced phase separation in phosphatidylserine, phosphatidylethanolamine and phosphatidylcholine mixed membranes. *Biochim. Biophys. Acta* **1981**, *643*, 276-282.
32. Sinn, C.; Antonietti, M.; Dimova, R. Binding of calcium to phosphatidylcholine-phosphatidylserine membranes. *Colloids Surf. A* **2006**, *282-283*, 410-419.
33. Majd, S.; Mayer, M. Hydrogel stamping of arrays of supported lipid bilayers with various lipid compositions for the screening of drug-membrane and protein-membrane interactions. *Angew. Chem., Int. Ed.* **2005**, *44*, 6697-6700.
34. Monson, C.F.; Cong, X.; Robison, A.D.; Pace, H.P.; Liu, C.; Poynton, M.F.; Cremer, P.S. Phosphatidylserine reversibly binds Cu^{2+} with extremely high affinity. *J. Am. Chem. Soc.* **2012**, *134*, 7773-7779.
35. Slater, T.F. Effect of copper on products of orcinol oxidation. *Nature* **1961**, *192*, 420-422.

36. Brown, K.L.; Conboy, J.C. Lipid flip-flop in binary membranes composed of phosphatidylserine and phosphatidylcholine. *J. Phys. Chem. B* **2013**, *117*, 15041-15050.
37. Liu, J.; Conboy, J.C. 1,2-Diacyl-phosphatidylcholine flip-flop measured directly by sum-frequency vibrational spectroscopy. *Biophys. J.* **2005**, *89*, 2522-2532.
38. Kornberg, R.D.; McConnell, H.M. Inside-outside trans-location of phospholipids in vesicle membranes. *Biochemistry* **1971**, *10*, 1111–1120.

Undercover Policing: Practices and Challenges

Lindsey Bonney

Weber State University

Abstract

Undercover policing is a unique and complex subject for justice professionals to explore. Developing from a rich history of infamous operations and court decisions, strike force teams are operated by some of the brightest and most talented officers. By gathering valuable intelligence from surveillance and the cultivation of confidential informants, undercover agents are able to effectively investigate and arrest criminal offenders that would unlikely be discovered otherwise. As with any position within the justice system, however, this type of work tests one's moral character and ethical behavior. This paper will attempt to explore these moral and ethical issues. Two roles, undercover officers and confidential informants, will be examined with a detailed discussion of the many dilemmas they face. This will provide a better understanding of the practices and challenges of today's undercover police.

After years pushing paperwork and moving countless offenders through the system, veteran Alcohol, Tobacco and Firearms (ATF)

officer William Queen began to lose interest in his job, and he longed to travel behind the handlebars of his beloved motorcycle. One morning, Queen's boss received a call from a previous confidential informant offering to take one agent undercover into one of the most notorious motorcycle gangs in America, the Mongols. Naturally, Queen was chosen for the position, ending the monotony and forever changing his life. Adopting the persona of Billy St. John, he quickly became "patched" into the gang and rose through the leadership ranks. St. John soon began serving as Treasurer, a role in which he gained access to records proving the gang's involvement in criminal activity. As a result, a powerful case was built, implicating several members. Such success, however, came at a high price as the lines between his duty to serve and his loyalty to the gang began to blur (Queen, 2005).

During his initiation into the gang, Billy was at the mercy of his fellow outlaw members who were constantly testing his loyalty and toughness. In fact, the members pressured him to engage in criminal acts, such as selling or using drugs, stealing motorcycles, and driving getaway cars. This soon became the norm and as St. John became accepted among the Mongols, he began to enjoy the camaraderie they shared together. On one occasion, he was even influenced to join a brawl with a rival gang, the Hells Angels, that led to three deaths and his eventual removal from the assignment (Queen, 2005). Queen's experience demonstrates the ability of undercover policing to infiltrate the criminal world to impose crime control. Although these infamous cases publicize the benefits of removing dangerous offenders from the streets, the challenges of the job should not be overshadowed by their success. This paper attempts to explore the development, practices, and challenges of today's undercover police.

What Is an Undercover Officer?

Shrouded in secrecy and mystique, undercover policing assigns officers to investigate a variety of crime problems, from street crimes to white collar crimes (Marx, 1982). Becoming a part of the criminal environment, officers are required to adopt fictitious identities for extended periods of time. This type of policing is considered to be essential for uncovering criminal activity that would likely remain unknown and unreported otherwise (Peak, 2012). According to Miller, Hess, and Orthmann (2011), two types of cover may be distinguished: light cover and deep cover. Light cover includes a regular shift in which officers may return to a normal life at home afterward. During light cover, officers may pose as an addict or dealer to conduct investigations and make arrests. Deep cover, on the other hand,

involves an officer assuming an identity for substantial periods of time to infiltrate a criminal group or organization (Miller, Hess, & Orthmann, 2011).

Regardless of the cover assigned, undercover policing requires a “carefully crafted persona” (Miller, Hess, & Orthmann, 2011). In fact, an agent’s effectiveness depends on his or her ability to blend in and resemble the offenders he or she seeks to investigate (Marx, 1982). To do this, it is important to maintain balance between fact and fiction. In other words, an officer must act as another while still incorporating his or her true identity. This helps lessen the possibility of revealing one’s cover, for the fewer the lies told, the fewer the lies there are to remember (Pogrebin & Poole, 1993). For instance, one agent stated that he uses his prior job experience when asked what he does for a living by offenders. This is helpful because he is able to provide great detail without having to remember which background he told to which offender (C. Bobrowski, personal communication, October 14, 2013). With such a unique role in law enforcement, it is important to explore how undercover policing emerged, what roles are carried out, and how agents are selected. These subjects will be discussed in the following sections.

History and Development of Undercover Policing

Since the turn of the century, the method of undercover policing has been used to effectuate the successful investigation and arrest of criminal offenders. However, this success has not always been recognized by justice professionals, for it was largely considered to be insignificant and marginal at best until the late 1970s and early 1980s (Marx, 1982). The change in attitudes toward such police tactics may be attributed to several historical events. First, infamous covert operations, like ABSCAM, increased the attention given to dealing with drug and white collar crime. Originating out of the Hauppauge, Long Island, Federal Bureau of Investigation (FBI) facility, ABSCAM sought to test the integrity of public officials by creating opportunities for corruption. By representing themselves as wealthy Arab sheiks, officers offered bribes to the officials in exchange for friendship and assistance. This investigation led to the exposure of several prominent congressmen, and undercover policing gained an overwhelming endorsement from the courts (Gershman, 1983).

Court decisions and provisions, such as the exclusionary rule, *Miranda*, and *Escobedo* also contributed to the rise of undercover policing. These case decisions and rules began to limit law enforcement’s abilities in the search, seizure, and apprehension of

offenders. Agencies then sought to develop creative ways around the rulings to maintain crime control. Coupled with covert tactics, advancements in technology, such as videotaping and audiotaping, helped to provide evidence of illicit behavior. The hidden surveillance also provided evidence ensuring that police were operating in an appropriate manner (Marx, 1982).

Next, the priorities of police work changed, as drug and organized crime began to increase dramatically in the mid-1980s (Bronitt, 2004). In fact, the establishment of sophisticated international distribution networks prompted the need for law enforcement to establish newer and more effective ways to combat crime problems (Marx, 1982). This contradicted the policies instituted by the infamous FBI director J. Edgar Hoover, which prohibited undercover policing. Hoover feared that such operations would reduce integrity and promote an “opportunity structure” to engage in corrupt practices (Pogrebin & Poole, 1993). Lastly, the publicity of successful operations helped change the attitudes of law enforcement officials. News stories and broadcasts acted as a deterrent, because offenders began to recognize that anyone they associated with criminally could be a cop (Marx, 1982).

Types of Undercover Policing

According to a study by Joh (2009), three types of undercover policing may be distinguished: surveillance, prevention, and facilitation. First, surveillance policing, or intelligence operations, seeks to gather information on crimes that have been completed, that are currently in progress, or that have yet to be executed. An anticipatory, rather than postliminary approach, surveillance policing tends to focus on low-level users or dealers that may have a connection to higher-level distributors (Joh, 2009). This approach is beneficial in obtaining information on every facet of the offender’s life, including where he or she lives, works, shops, dines, etc. It is also important to monitor with whom the offender associates and possible places where he or she obtains illicit drugs. Surveillance policing may occur in a variety of settings, such as prisons, near schools, bars, and other locations where an officer should be on the lookout for suspicious activity. Of the three types of undercover policing, it seems that surveillance policing is the most passive role (Joh, 2009).

Next, preventative policing requires more action than surveillance policing. Prevention seeks to stop an offense from taking place or make the commission of a crime more difficult. Agents may achieve this goal by attempting to weaken or divert a suspect from engaging in illegal

activity. For instance, as part of the ABSCAM operation, law enforcement agencies conducted “get rich quick” schemes to ensnare unsuspecting individuals, only to release them with a warning to deter them from future fraud (Gershman, 1983). Furthermore, prevention may also be achieved by strengthening victims or places that are more prone to victimization, often referred to as target hardening (Joh, 2009).

Lastly, facilitation may be considered the most active and controversial role in undercover policing. Contrary to preventative policing, facilitation seeks to encourage the commission of an offense by strengthening the opportunities for offenders and weakening the defenses of the victim. This is achieved when agents provide the resources or markets for illegal activity. Although this type of policing results in a quicker and higher amount of arrests than surveillance policing, facilitation is based on probabilities and temptation rather than reliable intelligence. Currently, it is not uncommon for undercover operations to begin without a specific suspicion, complaint, or suspect. Moreover, critics claim that this type of policing creates opportunities to engage in coercion and corruption to impose sufficient crime control (Joh, 2009).

Recruitment

The process of recruiting officers for undercover strike force teams is considered to be very intense and competitive. An elite group within or apart from a department, undercover officers enjoy prestige and recognition for their duties (Marx, 1982). As this type of policing is influenced by discretion and temptation toward illicit behavior, it is important to test the officer’s character, of integrity, honesty, fairness, loyalty, courage, and accountability (Pollock, 2012). To gauge his or her character, the officer is thoroughly screened for ethical professionalism and tendencies for substance abuse (C. Bobrowski, personal communication, October 14, 2013). Other techniques used for analyzing the officer’s reasoning skills and behavior include in-depth interviews consisting of several situational questions, polygraph exams, and drug urinalyses (Peak, 2012). These tests help to ensure that the officer will perform his or her duties both ethically and lawfully.

Dilemmas in Undercover Policing

The use of undercover policing is an important ethical dilemma to explore. In fact, many may question the propriety of this type of work, as it involves secrecy and the deception of the offender. Is it immoral for an officer to lie or deceive to protect the community? Is this an ill-accepted form of entrapment? Do agents enjoy too much discretion?

Do they abuse their power? Contrarily, it is important to consider the benefits of this type of policing, as undercover operations are responsible for arresting and prosecuting numerous offenders. This section will attempt to explore the moral and ethical issues relating to undercover work. Two roles, undercover officers and confidential informants, will be examined with a detailed discussion of the many dilemmas they may face.

Undercover Officers

Undercover officers work in a unique environment different from ordinary patrol officers. Patrol officers frequently respond to calls for service, removing criminals from the streets. Their authority to do so is clear as their uniforms, badge, and weapons are a visible sign to the public. Furthermore, a patrol officer has the ability to request backup assistance if he or she feels threatened or endangered by a situation (Miller, Hess, & Orthmann, 2011). Oppositely, however, undercover officers must become fully immersed in the world of street crime. Officers are stripped of their uniforms and dressed in plain clothes to fit the part and blend into the criminal subculture. Since much of undercover policing is solitary, officers must rely on their own moral reasoning and judgment skills (Joh, 2009).

Coercion and Deception

Many critics opine that undercover policing is a coercive and deceptive method of implicating offenders. In fact, Marx (1982) asserted that undercover policing has been criticized as a form of entrapment. Entrapment occurs when the government attempts to influence an individual to engage in crime that he or she would not ordinarily be predisposed to commit. However, Marx showed that most offenders, particularly drug addicts and dealers, are already predisposed and are not influenced by the objective methods of undercover agents. Lastly, Marx states that although these practices are legal, it does not mean that they are ethical.

Undercover policing is thought to consist of methods of trickery and temptation that pose questions of whether deviance in an offender is inherent or a conditional attribute. Mel Weinberg, a convicted con artist hired by the FBI, stated that if “you put the big honey pot out there, all the flies come to it” (Gershman, 1983). It seems that not all people have a price or can be drawn into engaging in crime, but there are certain behaviors that undercover tactics can turn up offenses a large proportion of the time. For instance, agents often target individuals with diminished capacity to resist temptation, such as

recovering alcoholics and addicts (Marx, 1982). This shows that some offenders may not be corrupt, but they are corruptible.

Discretion

As previously mentioned, undercover officers function in an isolated fashion. According to Pogrebin and Poole (1993), undercover officers enjoy wide discretionary and procedural latitude. This, coupled with minimal or nonexistent supervision from the department, allows undercover agents to “operate with fewer constraints, exercise more personal initiative, and enjoy greater professional autonomy” (Pogrebin & Poole, 1993, page 391). Officers are said to be held less accountable, and questionable practices may occur without punishment. In fact, unethical or illegal practices may even go unnoticed. For instance, an agent who was a part of the ABSCAM operation conducted numerous unwarranted searches in homes that were known or highly suspected of drug trafficking. Furthermore, the agent admitted to his conduct but explained he did so for the “noble cause” to fight the war on drugs (Gershman, 1983). This shows that when supervision is lacking, officers justify the means of using inappropriate practices to obtain the ends of catching criminals, a utilitarian perspective.

In addition to inadequate supervision, undercover strike forces have been shown to lack written policies. Departmental policies are beneficial because of the way they provide proper methods of operation and guide behavior. Policies are also effective because they establish the consequences for violating the rules and procedures (Peak, 2012). Even if an official policy has been established for an undercover strike force, it is typically either not known or not followed. Agents often devise their own procedures to accomplish objectives, relying heavily on their professional experience and judgment. This creates inconsistencies in how cases are handled and how offenders are treated. It may also be said that possessing such autonomy can be addicting and officers may develop a propensity to engage in more aggressive and risk-taking behaviors (Pogrebin & Poole, 1993).

Corruption

Immersion into the criminal world can be extremely challenging to an officer's beliefs and character. As an officer gains more years of experience or moves into a deeper cover, he or she becomes more vulnerable to corruption. Value systems begin to change and temptations increase toward the incentives of crime, such as money, drugs, sex, and alcohol. Furthermore, officers may begin to identify with their criminal associates and take on the “folkways, mores, and

customs of the criminal subculture” (Pogrebin & Poole, 1993, page 388). This breaks the conventional bonds to society, and officers start to question the laws they once swore to uphold (Pogrebin & Poole, 1993).

To reduce the risk of corruption, many departments have a policy or rule dictating the number of years an officer is allowed to serve undercover (Joh, 2009). Rotating officers back to patrol assignments, however, has proven to be very awkward and problematic. As an officer has grown accustomed to an exciting work environment, it is often difficult to come down from that “high.” Many officers feel that they have developed a talent for reducing a crime, and now that talent is being wasted. Moreover, many become dissatisfied with their new assignment because discretion is reduced and supervision is increased. This loss may lead to behavioral problems and result in the violation of rules and procedures. Officers also suffer from emotional and addiction problems, such as depression and alcoholism (Pogrebin & Poole, 1993).

Confidential Informants

One of the most important aspects of undercover policing is an agent’s ability to cultivate confidential informants (Peak, 2012). In fact, informants are fundamental in the intelligence-gathering process, because their compliance provides information of illicit activities and valuable contacts with active criminals (Pogrebin & Poole, 1993). Many confidential informants are found as a result of criminal investigations or arrests. In these instances, the individual agrees to cooperate with undercover agents in exchange for some type of incentive or consideration for charges that may be filed. With such close association with criminals, with both informers and targets, the challenges and risks of undercover work increase considerably.

Reliability

Although police informers provide valuable information to law enforcement, agents often refer to their use as a “necessary evil” (Harfield, 2012). Individuals that choose to cooperate and expose their fellow criminal associates are highly stigmatized and labeled as “snitches.” Many informants are seen as untrustworthy, as they often play a dual role of cooperativeness and deceit. According to Marx (1982), it is common for informants to continue engaging in criminal activity or drug use while working with law enforcement. Moreover, agents may then choose to ignore these crimes, especially if the informant has connections to more “heavy hitters.” From a utilitarian

perspective, the agents reason, it is better to “let the little fish go so we can fry the big fish” (Pogrebin & Poole, 1993).

When setting up an agreement, an agent should also consider the offender’s motivation to cooperate. The agent must then determine whether he or she will be able to maintain control over the informant’s actions. Pogrebin and Poole (1993) distinguish between three types of informant motivations. First, individuals that agree to work based on fear of criminal charges are easily controlled. The agent is able to instill that any violations of the set contract will result in a swift termination of services and filing of charges. Furthermore, those that agree to work for monetary compensation or out of revenge are easily controlled because the individual has incentive to act appropriately. Informants that work for fun, seeing it as a game, are more difficult to control. Many feel that they are smarter than others and engage in more outlandish and risk-taking behavior. As agents come across a variety of these types of personalities, it then becomes important to handle each informant with an individualized approach.

Incentives

According to a study by Pogrebin and Poole (1993), agents and confidential informants maintain a symbiotic relationship by exchanging services with each other. A “carrot-and-stick” approach, or offering incentives, is a common tactic used by agents to gain cooperation from their informants. Incentives may include dropping an informant’s case, lobbying for bail to be reduced, paying the informant to make deals, and dealing with their probation officers to not be so harsh with them. Agents have further pushed the boundaries of using incentives by going so far as to pay to get a car out of an impound lot and personally loaning the informant money (Harfield, 2012).

With such high rewards, however, come many challenges. Motivations may change in order to obtain additional incentives. This shift in motivation may lead to unethical practices with dramatic discoveries. For instance, an informant used in the ABSCAM operation was highly praised for his work, gaining the trust of many agents within the department. After working off his charges, the informant then began to receive a rather generous amount of money for his continued cooperation. During his time, the informant received almost \$133,180 and a book deal. What was later exposed, however, was the fact that the informant had manufactured/planted evidence and erroneously implicated several individuals. This led to several wrongful convictions, many of which were reversed (Marx, 1982). Although

most instances do not proliferate to this extreme, it seems that incentives may pose challenges or perceptions of impropriety.

Interpersonal Relationships

To effectively and ethically operate together, an agent and his or her informant must maintain a professional relationship. These relationships, however, have proven to be more complicated, often existing at opposite extremes. On one side, an agent may view informants with a utilitarian perspective. Informants are believed to be disposable and only serve an instrumental purpose, or a means to an end. As they are easily replaceable, informants seem akin to an endless assembly line, where one is followed by an identical other. Agents are often apathetic to the difficult situations informants face, and they feel no remorse for filing charges after the informant's work has finished (Pogrebin & Poole, 1993).

On the other side, a more intimate connection exists between the agent and the informant. As the agent and informant perform operations together, many hours are spent getting to know one another. Personal stories, of triumphs and strife, are shared, and friendships begin to develop. The agent often feels sorry for the problems his or her informant faces. The agent may also feel responsible for the informant's actions when he or she engages in criminal activity. Because of the friendship that has been built, the agent feels obligated or expected to engage in unethical practices, such as lying to protect the informant (Pogrebin & Poole, 1993). Other intimate relationships also exist, such as romantic affairs. This may also be seen as improper, and the informant's working services should be terminated (C. Bobrowski, personal communication, October 14, 2013).

Conclusions

Undercover policing is a unique and complex subject for justice professionals to explore. Developing from a rich history of infamous operations and court decisions, strike force teams are operated by some of the brightest and most talented officers. By gathering valuable intelligence from surveillance and the cultivation of confidential informants, undercover agents are able to effectively investigate and arrest criminal offenders that would unlikely be discovered otherwise. As with any position within the justice system, this type of work poses challenges to one's moral character and ethical behavior. Undercover officers face criticism for using deceptive and coercive tactics with wide discretionary and procedural latitude. Officers are also at risk for corruption, especially by working in deep cover or serving for

numerous years. The use of confidential informants may also be problematic, as they can be unreliable and motivated by the incentives they receive for service. Nevertheless, undercover policing is beneficial to the justice system, as its tactics evolve just as crime does.

References

Bronitt, S. (2004). The law in undercover policing: A comparative study of entrapment and covert interviewing in Australia, Canada and Europe. *Common Law World Review*, 33(1), 35-80.

Gershman, B.L. (1983). Toward a common law for undercover investigations: A book review of ABSCAM ethics: Moral issues and Deception in law enforcement. *Pace Law Faculty Publications*, 12(1), 185-207.

Harfield, C. (2012). Police informers and professional ethics. *Criminal Justice Ethics*, 31(2), 73-95.

Joh, E.E. (2009). Breaking the law to enforce it: Undercover police participation in crime. *Stanford Law Review*, 62(1), 155-198.

Marx, G.T. (1982). Who really gets stung? Some issues raised by the new police undercover work. *Crime & Delinquency*, 28, 165-195. doi:10.1177/001112878202800201

Miller, L.S., Hess, K.M., and Orthmann, C.H. (2011). *Community Policing: Partnerships for Problem Solving*. Belmont: Cengage Learning.

Peak, K.J. (2012). *Policing America: Challenges and Best Practices*. New Jersey: Pearson Education, Inc.

Pogrebin, M.R., and Poole, E.D. (1993). Vice isn't nice: A look at the effects of working undercover. *Journal of Criminal Justice*, 21, 383-394.

Pollock, J.M. (2012). *Ethical Dilemmas and Decisions in Criminal Justice*. Belmont: Cengage Learning.

Queen, W. (2005). *Under and Alone: The True Story of the Undercover Agent who Infiltrated America's Most Violent Outlaw Motorcycle Gang*. New York: Random House.

Anne Teresa De Keersmaecker's *Violin Phase* from a Jungian Perspective

Jon Thomas

Utah Valley University

Abstract

A critical analysis of Violin Phase by Anne Teresa de Keersmaecker from a Jungian perspective will reveal the power of ritual for the participant. An examination of written source material and a critical analysis of a recording of Violin Phase will yield answers to the following questions: How do Jung's theories provide insight into the way ritual is conceived? How do Jung's theories inform a discussion on dance? How does a critical analysis of Violin Phase reveal the power of ritual for the participant?

Simple swipes of the dancer's feet slowly progress into movement phrases that swirl the sand-filled stage into a mandala; creating an illusion of a seamless and timeless dream in Anne Teresa de Keersmaecker's choreography *Violin Phase*. It could be said that whoever performs in de Keersmaecker's dance enters a trance-like state that does not end until the final abrupt vocal breath.

The body has been used as a medium for entering a liminal state since ancient times by many individuals, from the Sufi Whirlers performing the Sema to the Pullava priests and priestesses performing the Serpent Ritual. The universal trance or liminal state achieved with the body takes individuals to the collective human experience inherent in every individual regardless of time and location. Rituals, such as the physical creation of a mandala, for example, are exercises that allow for persons to explore the “symbolic life” by “[making] their new vows or their meditations” (Jung). Archetypes, rituals, dreams, and collective universal subconscious findings were at the heart of exploration for Dr. Carl Jung’s theories in the early twentieth century. He argues that dreams and other manifestations of the unconscious “reveal to the dreamer hidden factors of [the dreamer’s] personality” and that “there must be a thorough-going, conscious assimilation of unconscious contents” (Jung). Jung emphasized the power of the arts, including dance, to help in this uncovering and assimilating of other manifestations of the unconscious when he remarked, “the creative process has feminine quality, and the creative work arises from unconscious depths” (Hayes).

A critical analysis of *Violin Phase* by Anne Teresa de Keersmaecker from a Jungian perspective will reveal the power of ritual for the participant. An examination of written source material and a critical analysis of a recording of *Violin Phase* will yield answers to the following questions:

How do Jung’s theories provide insight into the way ritual is conceived?

How do Jung’s theories inform a discussion on dance?

How does a critical analysis of *Violin Phase* reveal the power of ritual for the participant?

Carl Jung began his work with Dr. Sigmund Freud. Because Jung’s ideas into the inner psyche differed greatly from Freud’s, he found it important but devastating to branch off from his colleague’s theory and explore his own hypotheses. The major difference between his and Freud’s idea was his theory of the collective unconscious, which he saw as “a second psychic system of a collective, universal, and impersonal nature that is identical in all individuals. This collective unconscious does not develop individually but is inherited” (Moacanin).

The collective unconscious is said to contain universal ideals that are inherent in all human beings called archetypes (Shelburne). Archetypes are described as “the most ancient and the most universal thought-form of humanity. They are as much feelings as thoughts” and

“propensities in the human psyche that can express themselves in specific forms and meaning when activated” (Moacanin). Because archetypes are imageless, they must come up from the unconscious and be “clothed by the conscious mind in material from the external world” (New Princeton Encyclopedia of Poetry and Poetics). Thus, archetypes are unobservable in principle (Shelburne) and organized into archetypal symbols for the conscious mind to understand them.¹ An important archetypal symbol is the self, which is seen as a “construct that serves to express an unknowable essence” of the inner being (Moacanin).

Jung’s theory revolves around the self-incorporating individuation, which means “attaining ... a personal sense of balance, wholeness and self-knowledge while remaining true to oneself” (Yetwin). This balancing of the unconscious and the conscious mind as opposite facets of the psyche “requires an open communication ... a sensitivity to the signals of the unconscious” to achieve the personal balance (Moacanin). Dance, as it becomes a form of ritual, serves as a vehicle that helps the individual self in this individuation process.

Ritual can be characterized as “structures of sensorimotor experience that can be recruited for abstract conceptualization and reasoning” (Sotirova-Kohli) and “inherited behaviors...to produce certain behaviors when activated by the appropriate environmental releasing stimuli.” (Shelburne). Rituals give important reassurance, if they are long-standing traditions, that will help “give people the opportunity of interacting at a level that transcends that of the individual” and “project a form of guarantee, enabled by the presence of their ongoing existential stability” as well as “social integration.” This social integration occurs “on two levels: (1) within the group of people themselves; (2) in relation to the way the people view their historical or social past.” (Gruenwald).

Jung made the importance of ritual known when he stated, “Only the symbolic life can express the daily need of the soul” (Jung). It is also said that archetypes are infused into rituals as “archetypes represent patterns of behavior and are infused with distinctly numinous character when they appear” (Sotirova-Kohli). Ritual by nature, as a

¹ Dr. Walter Shelburne takes exceptional care to explain that “contents of the collective unconscious are in fact psychic contents which come into awareness but which are not the direct consequences of the individual’s own personal experiences.” Psychotherapist Dr. Radmila Moacanin distinguishes that the collective unconscious does not consist of “personal experiences that had been conscious at one time and then disappeared from consciousness...the personal unconscious...contains all the material that the individual has merely forgotten or repressed, either deliberately or unintentionally.”

conscious pattern of behavior, can be described as dance, is used to manifest archetypes, and manifests archetypes in concrete form as to make them available for assimilation into the conscious.

Dance is often seen as a “patterned and rhythmic bodily movement” that can transform “ordinary functional ... movement into extraordinary movement for extraordinary purposes” that facilitates the participant entering “a state of trance” that “may enable people to perform remarkable feats of strength, endurance or danger” (Dance). Two examples of dance’s power to transform movement into a medium that brings its participants into a trance state are the Serpent Ritual performed by the Pullava caste of India and the Sema performed by Whirling Dervishes.

The Serpent Ritual focuses on the creation, the sanctification, or the cleansing of the home of evil spirits or energy and the destruction of a mandala. The mandala is an inspired symbol that holds spiritual powers and purposes for certain religions. Jung concluded that “the mandala is an archetype of order, of psychic integration and wholeness, and appears as a natural attempt at self-healing” (Moacanin). In the Serpent Ritual, the Pullavas create a mandala, priests sanctify this work, and then the priestesses erase the mandala with a broom as they enter a rhythmic trance and dance on their haunches.

The Sema is a ritual performed to reach a “state of ecstasy” or a “trance-like closeness to God” (Zak). The dance consists of the participants whirling consistently in a counter-clockwise fashion “as if a spiritual energy is being received, passing through the heart and brought into this world as a service” (Gdula). This movement, although deceptively easy, is very systematic. The experience and training of the participant will dictate how well “they go to further stages of surrender” (Gdula). The Sema, as with the priestesses’ movement during the Serpent ritual, “adds a spiritual dimension to the general notion that movement is a unifying exercise” that “uses the power of dance to enhance worship” (Gdula). These rituals—and it can be concluded that almost any other ritual—uses movement as a means of connecting with a higher power as well as the inspiration within. This connection is due to the opening of the conscious mind of the participant to allow the archetypes of the unconscious to be identified more clearly. Feminine archetypes, in contrast to masculine archetypes, are more contemplative and calm and guide individuals to meditation. As the feminine archetypes are manifested more readily in dance, it can be deduced that dance provides a vehicle that allows the participant to take on a meditative state. This meditation provides balance to the masculine archetypes, which call for action and impulse. Without this

balance, the masculine archetypes can overrule an individual's life and cause for them to become hectic (Jung).

As some "meditation is about the release of consciousness and to focus on the process of thought entering and leaving" (Shapiro), it can be deduced that rituals, and dances that have ritualistic tendencies, are used as a form of meditation. As an important part of individuation is the ability to balance the unconscious communication to the conscious and the conscious mind's ability to organize the archetypes (Sotirova-Kohli), it can be said that the meditation that these dance forms facilitate help uncover the unconscious entities and bring them forward into our lived experience. Dance "is not liberation from the unconscious ... but rather a direct contact with the archetypal world in which the limiting confines of the ego adaptation are overcome" (Sotirova-Kohli). This journey can help the dancer "become aware of an enrichment of his being, of the existence within himself of something other than the familiar and ordinary." (Hayes). As the participant enters a meditative state through performing the ritual, archetypes manifest themselves in the movement. This power of the unconscious mind not only manifests "symbolically as archetypal images in ... creative art products" (Sotirova-Kohli) for the participant but also for the observer, as "the magic of theatre lies in the mysterious bond developed between performer and spectator" (Hayes). The process that occurs through a connection between the performer and observer helps facilitate the experiencing of the collective unconscious' archetypes and the process of individuation.

Jung himself said "a poet" (or dancers in this case) "using archetypes speaks in a voice stronger than [her or his own]" (N.F.). Jung often "discovered the collective unconscious through dreams and visions ... of his patients" (Moacanin). As the storytelling of dreams is an effective means of communicating and interpreting the collective unconscious, it can be said that the non-verbal language of movement, then, is not only beneficial kinesthetically to opening the participant to the unconscious but is also visually and ethnographically possible through the perception and replication of observers. As the dance is performed, it is

as though an electric current flows between the [performer and audience], an interplay goes on, the performer sensing subtle, instantaneous reactions from the audience to which he adjusts, subtly, instantaneously, in matters of timing, emphasis, and heightened imagination, and to which, in turn, the audience responds. An inspiring and memorable performance is not

achieved unless both artist and audience have an electrifying effect upon each other. (Hayes)

It is apparent that during the above-mentioned Serpent ritual “the sense of community that spectators share ... in the reaffirmation of an order that (according to the most revered traditions of Hindu thought) sustains and justifies all creation. Such is the power of a dance in a dance-centered culture” (Jonas). This reaffirmation and sense of community, along with further retrospection, allows all present entrance into the unconscious. The collective unconscious Jung describes for participant and observer opens through ritual as well as dance, allowing archetypes to manifest through the movement, perception, and reacting interplay between all present. This process is inherent as well in *Violin Phase*.

Violin Phase is a dance piece developed by Anne Teresa de Keersmaecker. It is set to Steve Reich’s music entitled *Violin Phase*. It is one of four movements in a larger work entitled *Fase: Four Movements to the Music of Steve Reich*. The work premiered in 1982 at the Beursschouwburg Theatre and opera in Brussels, Belgium. The record used for analysis is the dance for camera production of the piece that was directed in 2002 by Thierry de Mey.

The piece opens with de Keersmaecker standing in an area of sand inside a forest. The music *Violin Phase* by Steve Reich begins to fill the air. After several stanzas de Keersmaecker suddenly swings her arms from side to side (Anne Teresa de Keersmaecker). This movement ripples into her feet sliding across a circular pathway clockwise around the area of sand. The dancer continues developing the movement into jumps, leaps, and turns as she creates intersections in the sand. Alongside this physical development an emotional development parallels; intensity rises in her movement but also in her emotional state. Audible gasps, sighs, and sharp inhales throughout the work dictate this growing emotional intensity. As the dancer is in the highest emotional and physical state of movement and ecstasy, the music abruptly stops and startles her into stopping as well in the middle of the circular and intersecting pattern. De Keersmaecker holds still, only breathing as she looks down at the massive creation.

Similarly to the Serpent Ritual, *Violin Phase* revolves around the careful creation of a mandala she developed herself beforehand. De Keersmaecker reveals this point in an interview with Tate “so it is a very articulated space; a very articulated geometry that is drawn out very carefully. The geometrical pattern reveals itself ... more from above” (Anne Teresa de Keersmaecker). The movement quality is repetitious and sensual.

In addition, the turns begin to allow de Keersmaecker to constantly switch focus and to lose focus at moments entirely similarly to the way Sufi Whirlers do. Just as the Sema necessitates a surrendering to achieve ecstasy (Gdula), *Violin Phase* uses turns, whips, and jumps that require a surrender to fully achieve the piece's potential. These qualities help the dance create a ritualistic feeling not only in ceremony but in movement quality.

The mandala's location and shapes help provide groundwork for interpretation into the collective unconscious' inspiration. The sand is located in the middle of a forest. The Forest, as an archetypal symbol, in many instances alludes to discovery, especially when a character is forced to enter it to face the inner darkness (Guerin). The sand is strongly associated with spiritual aridity and hopelessness (Guerin). Jung's studies, mixed with his understanding of alchemy, witnesses that balance must be found through complete opposites, such as the conscious and unconscious, or in this case, extreme pressure and hopelessness and a drive and need to self-discovery (Moacanin). This extreme mixture of the opposing forces of suffering (sand) and discovery (forest) creates a natural balance for the viewer; the movement manifests an extreme need for the observer and participant to understand that inspiration is found in the most difficult and opposing of circumstances and challenges.

The beginning shape of the mandala is a large circle with a center point lightly etched in the sand, which represents sun and power (Kazmierczak). In the middle of the dance (6:36 in the recording) de Keersmaecker has developed this circle by adding a cross intersecting the center point. This cross-in-circle mandala has the potential to denote the sun and the four directions, the earth in astrology, and primal elements. Throughout the beginning and middle portion of the work, she moves clockwise to create this pattern. It can be deduced that this pattern in fact is a clockwise swastika, an ancient symbol of the sun, life, prosperity, happiness, and even consciousness and the psyche (Kazmierczak).² De Keersmaecker then immediately shifts her movement counter-clockwise while she creates spokes from the center that touch the outer circle; however, she does not travel the circle to

² The word "swastika" "...literally translates to 'may goodness prevail,' signifies goodness or wellbeing in Hindu, Buddhist and Jain religious contexts" (Dasgupta). Steven Heller, senior art director of the New York Times, through his research describes the swastika as "the icon of Nazism as a result of which it was transformed from a neutral vessel into an instrument of criminality." For the sake of interpretation past, historical interpretation of such symbols must be stripped away.

bring this new pathway to reveal a radiating sun. The end product of this mandala can be seen as images produced by the unconscious, consisting of a circle (which means unity, wholeness, or the psyche), crosses (which allude to struggle), triangles (alluding to communication) (Guerin), the central point denotes higher power or deity and the wheel with four intersections through the center; the mandala denotes the radiating sun and the monogram of Christ (Kazmierczak). Immediately after this image is focused on with a camera shot from above (at 10:00) de Keersmaecker deliberately reinforces the central point by swinging her right leg 14 times and shifts her weight in a way to make a half turn during each swing and changing her focal point.

The mandala may bring up a strong presence from the unconscious as this creative art relies on the feminine qualities of the work to bring forward the contents of the unconscious depths (Hayes) through archetypal symbol creation.³ The mandala has a variety of inspiration to give the audience and dancer alike as it provides connection to the unconscious. The shapes of circles, triangles, crosses, and the center point can provide further understanding into the struggle of audience and participant to communicate with something larger than themselves to find unifying and complete wholeness. De Keersmaecker herself remarked in her interview with Tateshots that “when you work the geometry with geometrical patterns what you do is like measuring the earth. It becomes about relationship, the amount of space you occupy in a certain amount of time” (Anne Teresa de Keersmaecker).

This plea being presented by the unconscious could be addressed to the world’s population in all four directions to move toward a more conscious and respectful relationship between all. However, the mandala must mirror a similar complexity to the psyche’s process of balancing. Therefore, these symbols can present new archetypes for one that another is not ready to receive at the time. However, all of the archetypes are innately there waiting to be uncovered. “That is the power of dance in a dance-centered culture” (Jonas). It is through the ritual of dance that these archetypes and relationships are made available to both performer and observer.

³ Although these symbols have a variety of meanings that have been presented, it is not the purpose of this interpretation to provide a concrete and singular meaning to the work being analyzed. Just as art has multiple facets and defies a singular observation de Keersmaecker’s work is given the same freedom. The interpretation’s purpose is to show the unconscious manifestations of archetypes in the work.

The power of this ritual is innate in the reaction of the participant and its shift throughout the piece. De Keersmaecker begins at the edge of the mandala, as if she has freshly entered there. Something sparks her simple swaying motion that continues to escalate into steps and slides and even eventually kicks, leaps and turns in which its build in kinesthetic surrender parallels the emotional breath and focus changes. The movement and behavior strongly reveal the emotional trance that she achieves. The breath and difference in effort from the beginning stillness to the abrupt and heightened stop at the end give clear evidence that the dancer left a different state than the one which she began. Every time the dance is performed, the ritual within it transforms participant and observer with a new and fresh experience. Close to the end of the dance (at 12:39), a development in the motif occurs where de Keersmaecker turns multiple times while traveling along the etched lines of the mandala. There are several moments during this motif where the dancer releases the head to look up in ecstasy and take a breath of exhilaration. There are several instances as well during this part of the development where focus is clearly indirect and constantly shifting. These two expressions of movement give a sense of timeliness, or a dream state, to the piece that is necessary for all rituals as they allow the performer to enter into a meditative state.

The collective unconscious needs the mind to be open and ready to receive its inspiration and to organize it; the ritual of dance is a vehicle for this process to occur. Jung's work in discovering and developing understanding took place primarily in dreams and visions of himself and his clients. The power of timeliness to create a dream-like state in *Violin Phase* facilitates meditation, through the vehicle of dance, allows for there to be nothing else on the mind and to focus as if by daydreaming. By the end the movement becomes violent and releasing. This parallels the priestesses of the Serpent Ritual and the Sufi Whirlers as they also take on a feeling of surrender and abandonment to the physical world as the participants enter into a realm of universal ideals. The dancer's movement denotes timeliness; this timeliness is very apparent when de Keersmaecker stops abruptly with the music, finds herself in the center of the mandala as if it has sucked her into its metaphorical realm, and then leaves during the last, sudden gasp for air. The performer's expression at the end is of surprise. De Keersmaecker's head immediately goes up toward the sky with eyes closed; hands ball into fists and arms retract close to the body in a protective manner. The dancer holds still for an instant, still surprised, and then releases her arms and head to look straight at the ground. Instead of immediately walking away or looking frantically about at the creation, De Keersmaecker merely stands still and feels the last burst of

energy slowly fade from her, the mandala, and the general area into the forest of unknown, potential exploration. The mandala is still in full creation standing as a testament to the journey of the participant and the observer.

Ritual is seen as a set of behaviors that are used for an extraordinary purpose. Jungian theory affirms that ritual's extraordinary purpose is to help bring forth essential principles, called archetypes, from the collective unconscious, that are universal to all individuals so that the conscious mind may organize them into daily habits and actions. The ritualistic properties of Anne Teresa de Keersmaecker's *Violin Phase* follow this template as there is a creation of a mandala, repetitious and developing movement, and an altered state of breath and presence that can arouse innate understanding within the collective unconscious and organized through assimilation by the individual's conscious self. Just as the Sufi Whirlers and the priests and priestesses performing the Serpent ritual receive inspiration from within and on high through their respective rituals, participants and observers of *Violin Phase*, either through participating kinesthetically or empathetically in the swipes and turns of the work, discover the power of ritual that is far deeper and greater than the eye and conscious mind can perceive alone.

Bibliography

"Anne Teresa De Keersmaecker." Tate, 12 July 2012. Web. Retrieved 9 June 2014 from <http://www.tate.org.uk/whats-on/tate-modern-tanks/exhibition/anne-teresa-de-keersmaecker>.

"Dance." *Funk & Wagnalls New World Encyclopedia* (2014): 1p. 1. Web. Retrieved December 5, 2014.

Dasgupta, Satarupa. "Revulsion versus reverence: The swastika and its symbolic significance." Conference Papers—International Communication Association (2009): 1-21. Communication & Mass Media Complete. Web. Retrieved December 18, 2014.

De Mey, T. (Director). (2002). *Rosas Fase* [Motion picture on DVD]. C-Sales.

Gdula, Kimberly. "Perfect Circles." *Dance Spirit* 5.7 (2001): 45-46. *Academic Search Premier*. Web. Retrieved December 8, 2014.

Gruenwald, Ithamar. "Ritual Theory in Ancient Israel." *AJS Review* 29.01 (2005): Vii+. Web. Retrieved November 20, 2014.

Guerin, Wilfred L. "Mythological and archetypal approaches." *A Handbook of Critical Approaches to Literature*. 3rd ed. New York: Harper & Row, 1966. 150-5. Print.

Hayes, Dorsha. "Consideration of the dance from a Jungian viewpoint." *Journal of Analytical Psychology* 4.2 (1959): 169-181. *Academic Search Premier*. Web. Retrieved December 8, 2014.

Jonas, Gerald. *Dancing: The Pleasure, Power, and Art of Movement*. New York: Harry N. Abrams in association with Thirteen/WNET, 1992. Print.

Jung, Carl. "The Symbolic Life." *Jung Society of Washington*. Web. Accessed November 27, 2015 from <http://www.jung.org/page-18179>.

Kazmierczak, Elizabieta. "From point to circle in primeval symbols." *Elka Books*. Elka Designs, 1 Jan. 1992. Web. Retrieved December 13, 2014.

Moacanin, Radmila. *The Essence of Jung's Psychology and Tibetan Buddhism: Western And Eastern Paths to the Heart*. New York: Wisdom Publications, 2012. eBook Collection (EBSCOhost). Web. Retrieved September 19, 2014.

The New Princeton Encyclopedia of Poetry and Poetics. Princeton, N.J.: Princeton UP, 1993. Print.

Shapiro, Deane H. *Meditation, Classic and Contemporary Perspectives*. New York: Aldine Pub., 1984. 5-7. Print.

Shelburne, Walter A. *Mythos and Logos in the Thought of Carl Jung: The Theory Of The Collective Unconscious in Scientific Perspective*. Albany, N.Y.: State University of New York Press, 1988. eBook Collection (EBSCOhost). Web. Retrieved December 3, 2014.

Sotirova-Kohli, M., Opwis, K., Roesler, C., Smith, S., Rosen, D., Vaid, J., and Djonov, V. 2013. Symbol/meaning paired-associate recall: an "archetypal memory" advantage? *Behavioral Sciences*, 3(4):541-561.

Yetwin, Neil B. "Thoreau, Jung, and the collective unconscious." *Thoreau Society Bulletin* 265 (2009): 4-7. Literary Reference Center. Web. Retrieved December 3, 2014.

Zak, Susannah. "Whirling Before Allah." *World & I* 9.5 (1994): 250. MasterFILE Premier. Web. Retrieved December 8, 2014.

Abstracts

ARTS

The Intellectual Simulacrum: Landscape Photography, Intellectual Property, and Claiming the American West

Courtney R. Davis

Utah Valley University

During the second half of the nineteenth century, scientific and photographic expeditions abounded in the western United States. From large-scale, government-backed expeditions, like the Hayden and Wheeler Surveys, to more intimate, self-funded explorations, photographers produced negatives by the tens of thousands. Often shouldering great physical risk to obtain the perfect view, the explorer-photographers earned immediate admiration with their images of the wilds of the American West, from Yosemite to Yellowstone, the Sierra Nevadas to the Rockies. But the frontier photographers did more than capture the sublime wonders of hither-unseen panoramas: they charted the American West visually, bringing landscape under the control of modern technology. By transforming landscape into a fixed image, it could be argued that the western landscape photographers staked a claim of visual ownership through the auspices of intellectual property law. This paper proposes that frontier photographers used photography as a method to control and even to commoditize the western American landscape and that such images contributed to the taming of the West through industrialized technology. Support for this argument comes from statutory and case law, such as the Copyright Act of 1865, which extended copyright protection to photography, and the landmark case that followed, *Burrow-Giles Lithographic Co. v. Sarony* (1884). Photographs, particularly landscape imagery, functioned as a “miniature of reality,” to borrow a phrase from Roland Barthes. In this intellectual simulacrum, explorers colonized every detail of the western landscape, visually claiming not only terrain and topography, but also aesthetics and intellectual property.

ARTS

The Nutcracker Ballet as a Reflection of American Cultural Values

Tessa Dastrup

Utah Valley University

A party, a Christmas tree, mice, soldiers, a nutcracker, falling snow, and the sugar plum fairy, what do all these things have in common? If you ask anyone in America, they most likely will reply, "The Nutcracker." Since its arrival in the mid-twentieth century, this ballet has sparked something in the hearts of Americans and has been performed in cities all across the country for generations. Because of the collective cultural impact of this particular ballet, information regarding the culture can be discovered through the dancing. Throughout history, dance is found in all societies and is used as a language to communicate "...fundamental values, aesthetics, and mores. (Jonas 9)" One way to look at dance and how it reflects the culture is through a new historicism frame of analysis. Through this research model, the assumption is that the work is connected to its time and place and reflects the culture. By applying new historicism to written source materials and video footage of The Nutcracker, portrayals of American cultural values will be found within the dancing. This will lead to a deeper examination of the popularity of The Nutcracker with the American audience, which can help uncover the beliefs and ideals of a nuclear family with specific gender roles, the essence of God and binary opposition, and individual worth along with the melting-pot mythos with which the American culture identifies. This means that by looking at The Nutcracker through a new historicism lens, underneath all the sugar, snow, and tutus, one can find a deeper meaning of American cultural values lying within the tradition.

ARTS

How Does the Decision to Censor Art Impact the Museum?

Loclyn Torres

Utah Valley University

As art has become increasingly more shocking, museums have been faced with the challenge of displaying this provocative new art in a way that enlightens rather than offends. Nevertheless, when the integrity of an artwork is questioned, many museums find themselves terribly unprepared to handle these sensitive situations in a delicate and decisive manner. This causes museums to react rather than act. One incredibly problematic reaction that a surprising number of museums result to is censorship. In such cases, instead of actually addressing the viewers' concerns, censorship simply takes that questionable work of art out of the conversation. In addition, picking and choosing what art is okay to show based on personal morals and beliefs is undemocratic and violates the equality that is central to the First Amendment. While the original cause of censorship may be to avoid controversy, the act of censoring in and of itself is often the biggest source of controversy. To figure out some of the main causes behind the decision to censor, I examined the events surrounding four compelling cases of censorship: Robert Mapplethorpe and the Corcoran Gallery of Art in 1989, David Wojnarowicz and the National Portrait Gallery in 2010, "A Child's View of Gaza" and Oakland's Museum of Children's Art in 2011, as well as Rodin and the BYU Museum of Art in 1997. In addition to revealing the cause of the censorship, a further study of these cases gives insight into how censorship affects the museum, both long term and short term, and the impact censorship has on how successfully museums fulfill their purpose.

ARTS

Political Implications of the Ballet Giselle

Rose Hutchins

Utah Valley University

This research explores the relationship between the sociopolitical turmoil among French citizens during the July Monarchy (1830–1848)

and the original production of the Romantic ballet *Giselle* (1841). Often considered to be the quintessential Romantic ballet, *Giselle* has traditionally been interpreted by focusing on typical characteristics of Romanticism, such as emotionally driven plot lines, a love of the fantastic, nationalism, and the idea of unattainable love. However, failing to also consider the sociopolitical milieu of the time of *Giselle*'s premiere gives a limited picture of the meaning within the ballet. A critical analysis of *Giselle* from a New Historicism perspective provides a more complete understanding of this Romantic ballet by illuminating underlying social and political tensions among the French citizens during the period preceding the French Second Republic. This research was conducted from a New Historicism perspective by reviewing source material and critically analyzing the ballet *Giselle*. The use of New Historicism, a frame of analysis that places historical events within their cultural context, assisted in drawing connections between *Giselle* and surrounding events of Paris, France, during the mid-1800s. The French sociopolitical environment was turbulent in the years leading up to and following *Giselle*'s premiere because of conflicts between the two main political factions of the July Monarchy: the *parti de résistance* and the *parti du mouvement*. The results of this research demonstrate that the ballet *Giselle* reflects this political turmoil, both in its dancing and in its plot line. These findings are significant because they show that dance is both indicative of a culture's current climate, as well as a vehicle for political expression that contributes to shaping its country's future identity.

ARTS

The Symphony and the Ballet: Select Works of Tchaikovsky as Collaborative Communication Tools in Music and Dance Education

Justine Sheedy-Kramer

Utah Valley University

The significant influence of Pyotr Ilyich Tchaikovsky's compositions is readily apparent in the fields of both music and dance. With careful analysis, however, several of these works provide the opportunity to create a stronger understanding between students and artists in these art forms. There are unique connections to be discovered within Tchaikovsky's compositions, particularly his symphonies and ballets.

By engaging students in discovering similarities between the compositional components of these works, an opportunity for increased comprehension and practical application can be developed. Students and artists can find mutual understanding through compositional elements such as form, structure, theme, melody, harmony, motif, and instrumentation. In addition, discussion points arise from the elements of time and place, as both the symphony and full-length classical ballet reached a pinnacle of success and popularity during the late 19th-century. Tchaikovsky's works were critical to this success and are essential tools for comprehension across music and dance. Musicians, conductors, dancers, and choreographers may all benefit from a greater understanding of how these compositions significantly enhanced the symbiotic relationship between the two art forms. Practical analysis within Tchaikovsky's works offers deeper insight into the connections between his symphonies and ballets, develops a bridge between the performances of these works from the original to the current, and presents learning opportunities for future collaborators.

BIOLOGICAL SCIENCES

Effect of Mercury Chloride on the Brine Shrimp *Artemia*

Nicole Berthelemy & Dustin Ingraham

Weber State University

The brine shrimp *Artemia* from the Great Salt Lake are exposed to increasing levels of various toxins dumped in the lake by surrounding towns and industries. These toxins, in particular mercury, bioaccumulate through the food chain and have led to advisories against eating certain waterfowl species. The objectives of this work are to 1) define the acute and chronic effects of mercury chloride on *Artemia*'s life parameters and 2) quantify the shrimp biochemical response to the mercury exposure using a series of biochemical markers, among them, superoxide dismutase (SOD), reduced glutathione (GSH) and lipid peroxide (LPO), and heat shock proteins 70 (Hsp70) and 90 (Hsp90). Adult and larval shrimp exposed to 10^{-1} g/L⁻¹ HgCl₂ for 24 hours suffered one hundred percent mortality, regardless of salinity or temperature. Shrimp subjected to 10^{-2} g/L⁻¹ HgCl₂ or less had a noticeably better survival rate, although it was modulated by temperature and life stage. The highest concentration with no observable adverse effect was at 10^{-4} g/L⁻¹ HgCl₂ in adults at 25°C. All

shrimp raised into 10^{-2} g/L⁻¹ HgCl₂ or higher HgCl₂ concentrations died before reaching maturity. Shrimp placed in 10^{-4} and 10^{-3} g/L⁻¹ HgCl₂ matured at a significantly slower rate, in 51 and 43.5 days, respectively, compared with 36.2 days in the control. The numbers of eggs per brood produced under these conditions were significantly lower, 24 and 34, respectively, compared with 52 eggs per brood in the control. Solutions with 10^{-5} g/L⁻¹ or lower HgCl₂ had no effect on shrimp survival, maturation, or fertility. Shrimp exposed to HgCl₂ concentrations ranging from 10^{-1} to 10^{-3} g/L⁻¹ HgCl₂ for 24 h strongly expressed Hsp70. Shrimp surviving a 48-h exposure in 10^{-3} and 10^{-4} g/L⁻¹ HgCl₂ expressed Hsp70 in higher amount compared with the control.

BIOLOGICAL SCIENCES

A Surplus of Ph.D.s, Research Productivity, and its Effect on Life Science Departments

Nile Carrethers, Jonathon C. Marshall, Tyson Schwab, Geoff Beck, Cody D. Zesiger, & Leticia Alvarez

Weber State University, University of Utah, University of Utah School of Medicine

During the last several decades, we have seen an ever-increasing number of Life Science students pursuing graduate school and eventually earning Ph.D.s. This trend, coupled with a flat-lining of the number of tenure-track jobs available during this same time period, has created a hypercompetitive job market. Previous research has quantified and discussed potential ramifications of this trend. Here, we present the effect this has had on average researcher productivity, quantified by the common h index metric, for tenure-track faculty at undergraduate, Masters-granting, and Ph.D.-granting universities. During 2009–2012, we gathered h-index scores and calculated mean h-index scores for tenure-track and tenured faculty in Life Science departments from a representative sample of universities in the states of Utah and Rhode Island. We did the same for a selected number of high-profile undergraduate liberal arts colleges. We found small differences between the average h-index mean scores for all tenure-track faculty at undergraduate, Masters, and Ph.D. universities as well as small differences between tenure-track and tenured faculty at undergraduate and Masters universities. The largest differences in average h-index scores occurred between tenure-track and tenured faculty at Ph.D. universities. We conclude our presentation with an interpretation and

discussion of this trend and suggestions on how universities can best utilize the current situation.

BIOLOGICAL SCIENCES

Sequencing and Annotation of Novel Plasmids in *Lactobacillus curvatus*

**Michele Culumber, Jordan Hendricks, Craig Oberg, Taylor
Oberg, Donald McMahon, & Jeff Broadbent**
Weber State University

Lactobacillus curvatus, a non-starter lactic acid bacteria (NSLAB), is rapidly becoming the most prevalent NSLAB strain isolated from aged Cheddar cheese. Plasmids often carry genes that confer advantageous traits that may provide a survival advantage to *Lb. curvatus* in cheese. Understanding the genotype of these plasmids could provide important information concerning genes that allow *Lb. curvatus* an advantage in the cheese environment. Plasmids were isolated from two different strains of *Lb. curvatus*, WSU-1 and LFC-1. These strains were isolated from distinct geographical areas. WSU-1 contained seven plasmids while four plasmids were detected in LFC-1. Similarities, at least in size, exist between the largest (40-kb) and smallest (1240-bp) plasmids in both *Lb. curvatus* strains. The genomes of both strains have been sequenced and several putative plasmid contigs identified. These sequences were paired with similarly sized plasmids isolated from the organisms, and the identified open reading frames were compared. Each strain contained a plasmid, of different sizes, with nearly identical genes that coded for an anti-toxin part of a toxin-antitoxin system. These plasmid contigs also coded for cation transport proteins that could promote survival in aging cheese. Variation in plasmid profiles between the two *Lb. curvatus* strains also suggests multiple strains may be circulating in cheese plants. WSU-1 and LFC-1 strains carry a greater complement of plasmids than are typically found in dairy lactobacilli. Maintaining a large set of plasmids has a high metabolic cost to the cell, indicating these plasmids contain genes that have value to the organism.

BIOLOGICAL SCIENCES

Mutant Phase Bacteria and Their Role in Public Health

Brent Hunt

Dixie State University

Cell-wall-deficient bacteria are hugely important factors in human health. The idea that blood is sterile is fast becoming a myth for at least 40% of our population. Studies of human blood have shown that between the ages of 18 and 80, over 40% of subjects carry at least one cell-wall-deficient bacterium, and those who carry one are more than likely carrying multiples. For years, many common bacteria related to the skin and scalp have been considered harmless bacteria. With the emergence of *Propioni acnes* and *Staphylococcus epidermis* in prosthetic joint infection, these bacteria are now viewed as dangerous infectors, but it is unclear how these commensal skin bacteria access the joint or other manmade devices. Surgeons are confident these infecting agents are introduced in the operating room. Our data suggest these bacteria are circulating in the blood long before the surgery. L-form varieties of many classic bacteria are potentially in thousands of patients who are awaiting a procedure that has a 5–10% probability of resulting in an infection. These and other potential infectors can be found in a single drop of blood. To date, I have isolated over 20 certified L-form bacteria in the blood of 150 participants. The presence of these bacteria is predictive of disease and affects the daily health of those who carry them. These mutant-phase bacteria appear in a variety of sizes and shapes as they thrive and continually morph within human and animal bodies.

BIOLOGICAL SCIENCES

Phylogenetic Studies of the Utah Endemic Plant Tushar Mountain Draba (*Draba ramulosa*)

Matt Hutchinson, Sadie Larsen, & Jim Harris

Utah Valley University

Draba is the largest genus in the Mustard Family (Brassicaceae), with approximately 350 species. The center of diversity in the genus is western North America, making it ideally suited for phylogenetic

research in this region. *Draba ramulosa* is endemic to the Tushar Mountains of south-central Utah and is believed to be a hybrid of two other *Draba* species. Because *Draba sobolifera* is also endemic to the Tushar Mountains, and because it is morphologically similar to *D. ramulosa*, the two species have been considered closely related. In fact, there has been speculation that *D. ramulosa* is of hybrid origin with *D. sobolifera* as one of the parents. It has been hypothesized that the second parent is an unknown white-flowered species; however, DNA sequencing of the internal transcribed spacer (ITS) gene and chromosome counts in our study have shown that *D. ramulosa* is probably not of hybrid origin nor closely related to *D. sobolifera*. *Draba pennellii*, a white-flowered species of the Deep Creek Mountains in the western part of Utah, has an identical ITS gene sequence to that of *D. ramulosa*, suggesting that it is the closest relative of *D. ramulosa*.

BIOLOGICAL SCIENCES

Novel *Lactobacillus* Associated with Late Gas Production in Aged Cheese

Lauren Montierth, Craig Oberg, & Michele Culumber

Weber State University

A new species of non-starter lactic acid bacteria (NSLAB), called *Lactobacillus wasatchii* WDC04, was identified in aged Cheddar cheese manufactured in northern Utah. This bacterium has been linked to gas formation in the latter stages of Cheddar cheese ripening. It is an obligate heterofermentative NSLAB shown to produce gas in broth cultures under the conditions of cheese aging. WDC04 prefers growth on ribose at low pH (5.0–5.5). It grows slowly at cold temperatures, which could play a role in its ability to create gas defects in aging cheese. In aging cheese, gas formation causes swelling of the packaging and splitting of the cheese, making it unfit for consumer use. Twenty-seven aged Cheddar cheeses from around the world were tested for WDC04 using MRS medium amended with 1.5% ribose at pH 5.2 and incubated for 1 to 4 weeks. Isolates were identified using 16S rRNA gene sequencing and then compared to the Genbank database and to the 16S rRNA gene from *Lb. wasatchii* WDC04. No *Lb. wasatchii* were detected in cheeses without gas defects. It was found, however, in two distinct aged commercial Cheddar cheeses, produced in a facility geographically distant from the original isolation location

that exhibited late gas production. These results indicate *Lb. wasatchii* is more widespread than previously thought and appears to be a causative agent of late gas defect in aged Cheddar cheeses.

BIOLOGICAL SCIENCES

Method to Survey Seasonality of the Great Salt Lake Virosphere

**Jakob Oberg, Heather Thomas, Kayla Blackford, Tyler Allen,
Craig Oberg, & Matt Domek**

Weber State University

Bacteriophages play an important role in controlling bacterial populations and nutrient recycling the Great Salt Lake (GSL) but little is known about the impact of seasonal changes in temperature, salinity, and nutrient availability on the GSL virosphere. Part of the difficulty is having a reliable and rapid method to monitor multiple bacteriophages in the GSL. In this study, we developed methodology to survey the GSL virosphere and its diversity utilizing four strains of *Salinivibrio* (SA36, SA39, SA40, and SA50), all previously isolated from the GSL, as a model system. GSL water samples were taken seasonally and filtered to remove bacteria. Three methods were used to enumerate phage: spot testing on known hosts, TEM examination of GSL samples, and lysis curves using automated spectrophotometry. Spot plating and TEM as monitoring methods proved inconclusive, although bacteriophages with recognizable morphologies were observed with TEM. Lysis curves, however, allowed bacteriophage enrichment with each host enhancing host lysis detection. Results showed bacteriophage were detected for SA39 in summer, autumn, and winter, while bacteriophage for strain SA50 were found primarily in the summer months. Dilution of the sample with sterile distilled water (1:2) increased the rise the bacterial growth curve log phase allowing phage lysis to occur more rapidly. Understanding the GSL virosphere can lead to better methods of maintaining the GSL ecosystem and monitoring its response to seasonal changes or environmental disturbances.

BIOLOGICAL SCIENCES

Detection of Halophilic Bacteriophage in Soils near the Great Salt Lake

Garrett Ward, Matthew Domek, & Michele Culumber

Weber State University

Bacteriophages are viruses that infect bacteria and thereby control the bacterial populations in an environment. Bacteriophages that target *Salinivibrio* strains from the Great Salt Lake (GSL) have been isolated and studied, but little is known about the distribution of bacteriophages in the soil surrounding the GSL. The objective of this project was to develop a method to amplify and isolate bacteriophages from the soil, so we can gain a greater understanding of the role they play in the terrestrial ecosystem. Soil samples were collected from Antelope Island (in GSL) at various distances from the water. *Salinivibrio* strains SA36, SA39, SA40, SA50, and B1 and halophilic broth were added to 10 g of each soil sample. The liquid was removed and purified through filtration and centrifugation and then spotted onto a lawn of *Salinivibrio*. Plates were then observed for plaques formed when bacteriophages infect the host. We used this technique to test known bacteriophage–host pairs, but not all pairs amplified equally well in soil. Amplification of bacteriophage only occurred with strains SA30 and SA40. This may indicate that the bacteriophages bind to soil particles or are inactivated by soil components. Two potentially new bacteriophages were isolated from soil samples. These bacteriophages were amplified and observed with an electron microscope. Most of the samples revealed 100- to 1000-fold bacteriophage amplification. This method provides a practical way to find bacteriophages in soils by amplifying them to a detectable concentration.

BUSINESS

Determinants of Life Expectancies in U.S. Counties, 2010

Dwight Israelson

Utah State University

We develop and test a preliminary model of the impact of demographic, economic, education, and social factors on life

expectancy by county for males and females born in 2010. We find that median mortgage payments, the percent foreign-born, the percent speaking a language other than English at home, local government revenue and employment per 1000 population, the percent with some higher education, the percent of the population urban, the percent of the population White, the percent of the population Indian, and the percent of married households are significantly positively associated with life expectancy for both males and females, whereas the poverty rate, unemployment rate, average household size, and percent Black are significantly negatively associated with life expectancy. For males, per capita population density is negatively associated. For females, median age of the female population in the county is also significantly positively associated with life expectancy and median rent is negatively associated with life expectancy. In addition, the percent of the county population who voted in the 2008 Presidential election is positively related to life expectancy for both males and females.

BUSINESS

Exploring Comparative Employee Engagement

Aaron Barrus, Sean Costello, Garret Beaman, & Jonathan Westover

Utah Valley University

In an increasingly hypercompetitive and interconnected globalized world and with much of the business world trying to pinpoint reasons why certain companies are successful and others are not, the topic of employee engagement is frequently discussed and debated. Furthermore, employee engagement has repeatedly been shown to directly impact a variety of individual, organizational, and societal outcomes, including employee motivation, satisfaction, and overall performance levels. With the results of a 2013 Gallup Poll on worldwide workforce engagement showing that only 13% of the world's workforce is actively engaged in their work and while the idea of employee disengagement is widespread across industries and companies, there are companies that are taking proactive measures to boost employee engagement. This research uses a case methodology and utilizes the Gallup Q12 (survey questions that identify the key drivers of worker engagement in a variety of contexts) as a framework for understanding comparative workplace engagement. Additionally, this research specifically examines Google, Facebook, Twitter,

LinkedIn, Boston Consulting Group, and Bain and Company (six of the companies that are repeatedly listed as best places to work according to Forbes, Fortune, Wall Street Journal, and Glassdoor and looks to find recurring employee engagement trends among these companies (including elements of institutionalized organizational culture, policy, and practice). Conclusions and practical recommendations will be provided to help organizational leaders further engage their employees and drive higher levels of individual and organizational performance.

BUSINESS

The Relationship between Organizational Strategy and Fraud: The Case of John McNamara

Jonathan El-Bakri, Chad Albrecht, & Conan Albrecht

Utah State University and Brigham Young University

The purpose of our paper is to better understand the relationship between organizational strategy and fraud prevention and detection. To better understand how the occurrence of fraud provides a competitive disadvantage to an organization, our paper examines the case of John McNamara, who, in the 1990s, used a Ponzi-type fraud scheme to defraud General Motors of roughly \$436 million over an 11-year period. The case illustrates how General Motors suffered competitive disadvantages because of the fraud and highlights the importance of proactively educating fraud prevention and detection at the highest levels of the organization. Our paper further argues that organizations that experience fraud suffer a significant strategic and business disadvantage when compared to competing firms in the marketplace.

BUSINESS

What if the UASAL Really, Really Mattered? A Strategic Vision

Douglas K Peterson

University of Wyoming

What if the UASAL could make itself really matter to Utah? An outgoing board member seeks to present a few ways for the UASAL to

make a concerted splash for cross-disciplinary academic congress, innovation, presentation, and discourse. With the strategic capabilities it currently possesses, it could serve as a sounding board for the wide and interconnected web of knowledge and understanding today, looking not in the past, but into our understanding of the future. At least four ideas are presented for thought. First, is it possible to create a truly cross-disciplinary division apart from what we currently have? Second, can our divisions split into smaller cross-disciplinary academies while finding resources? Third, can we establish another major award, perhaps the recognition of major holistic contributions to Utah? Finally, can we open the UASAL to major speakers from organization such as the Santa Fe Institute, the Aspen Institute, The Yellowstone Institute, the Secure the Future Foundation? The cross-recognition and integration of the mess map of knowledge could truly inform ourselves, the academies, our thoughts, and our resources to become truly a major player serving Utah.

BUSINESS

Towards a Better Understanding of Financial Information and Metrics for HR Professionals

Adam Condi, Tim Gardner, Chad Albrecht, & Scott Allred
Utah State University

Over the last century, the role of human resources (HR) within the firm has changed significantly. As a result of this change, the HR department has evolved from an institution primarily focused on legal compliance and working with unions to an institution that is focused on helping organizations implement strategy and add value. In our paper, we report the results of a series of interviews with a board member of several Fortune 500 companies to better understand the critical financial information—including financial statement metrics and financial ratios—that HR professionals must know to add value and “elevate strategy discussion.” Our preliminary research suggests that HR professionals can make positive contributions to strategy discussions when they have an increased understanding of various income statement numbers and metrics, including targeted revenues; targeted cost of goods sold and gross margin percentages; targeted selling expenses, research and development, and general and administrative expense margins; and targeted profit margin and earnings per share numbers. Our analysis suggests critical areas of the

balance sheet include an understanding of cash balances, receivables, and inventory, with the most important financial ratios being: 1) days in accounts receivable and 2) days in inventory and inventory turnover ratio. In this paper, we will map out what typical HR professionals know about these important financial measures, how this compares to what they are expected to know, and the benefits for both HR careers and company bottom lines of understanding this important area of knowledge.

BUSINESS

The Distribution of Life Expectancies Within U.S. States, 2010

Dwight Israelson

Utah State University

Previous studies on life expectancy by U.S. county have found large differences among counties in life expectancy at birth for both males and females. Various determinants of these differences have been identified, including economic, education, demographic, social, geographic, climatic, and environmental factors. This study uses life expectancy by county to calculate the relative inequality in life expectancy within states in 2010. Gini coefficients for life expectancy are calculated for each state, and separate Gini coefficients are calculated for men and for women. The Gini coefficients are obtained from county average life expectancies by weighting each county life expectancy by county population, then calculating the Gini coefficient from the resulting Lorenz curve. A model of the determinants of within-state life expectancy inequality is identified and tested using regression analysis. Dependent variables in the model include Gini coefficients for various economic, demographic, and social factors calculated from county data in the same manner as are the life-expectancy Gini coefficients. Economic variables in the model include Gini coefficients for income and poverty level. Demographic variables include Gini coefficients for percent of county population White, percent urban, and age. Social variables include Gini coefficients for educational attainment. Environmental variables include pollution indices. Separate regressions are also run for male and female life expectancy Gini coefficients. Relative inequality in population life expectancy within states was found to increase with relative inequality within states in poverty rate, urbanization, percent White, air pollution

and age. Relative inequality in female life expectancy within states increases with relative inequality in poverty rate, percent White, and air pollution; and relative inequality in male life expectancy within states increases with relative inequality in poverty rate, education, and percent White.

BUSINESS

An Exploratory Investigation of Gender and Cross-Major Differences in Business Student Successes in an IT Course

Jin Zhang & Wayne Huang

Weber State University

Employing a variety of quantitative research methods (T-tests, ANOVA tests, post-hoc tests, etc.) and administering one comprehensive MS Access project, one comprehensive MS Excel project, eight timed quizzes, and three timed exams, this study monitored and analyzed academic performances of over 190 business students in an IT course offered at a major public university in the U.S. across two academic years. The study specifically investigated potential gender differences and potential differences across majors in business student successes in an IT course. Whereas male students seem to have achieved slightly higher performance scores on the MS Access project and on exams, female students achieved higher scores on the MS Excel project, on quizzes, and on overall performances; however, none of those differences was statistically significant. While average performance scores differed quite noticeably across seven different major groups (Accounting, Business Management, Finance, Human Resource Management, Marketing, Supply Chain Management, Others) on the MS Access project, the MS Excel project, quizzes, exams, and overall performance, almost all such differences were statistically insignificant with one exception: accounting majors performed significantly better than supply chain management majors on quizzes.

BUSINESS

Study to Teach, Teach to Learn, Learn to Apply

Shandon Gubler

Dixie State University

Recent academic research has attacked the notion of individual learning styles and emphasized learning by personalized “meaning” and learning by “self-explanations.” The challenge is that “meaning” cannot be taught; it must be discovered by the individual student. An effective means for students to discover meaning for themselves is by “Studying to Teach” content to a CEO, then “Teaching to Learn” by engaging the theory of real-time self-explanations while actually teaching a CEO, then listening to the CEO explain how the content is applied in the real-world to produce desired results. Each academic year, just two Business Ethics classes at Dixie State University create more than 936 touch points between students and business community members through this pedagogy practice, thus giving students a real-world reality check on how business ethics are, or are not, being applied, or how they could, or should, be applied. CEOs are receiving valuable exposure and training in newly emerging business topics, thus providing them a competitive edge in their marketplace.

EDUCATION

Including the How: Quality of Revision and Implications for the Teacher-Student Writing Conference

Christopher Lee, Angie Carter, Aaron Gates, & Tayler Brown

Utah Valley University

While limited empirical research has been performed on the efficacy of the writing conference (a consultation between student and teacher designed to improve student writing), little systematic research has been done connecting student perceptions of the writing conference to what occurs in the conference and subsequent revision. Our research seeks to remedy these gaps to discover what the writing conference accomplishes in terms of producing better writing, what the student expectations are, and how power dynamics affect the quality and

quantity of revision from both student and instructor perspectives. Our principle research question is "What is the relationship between types of teacher–student interaction within the conference and subsequent revision of students' papers?" Because little data exists analyzing teacher–student conferences from a student perspective, our study incorporates undergraduate researchers to provide a student perspective on the purpose and effectiveness of the writing conference. The three types of data collected for this study include recordings of the writing conferences, rough and final drafts of student papers, and three surveys with the purpose of capturing student expectations and views pre-conference, post-conference, and post-final grade. Results from the three data types indicate that although the writing conference does seem to aid students in improving written work, revisions remain relatively insignificant in terms of global, substantial improvements. The conference transcripts indicate that the amount of time spent discussing content problems as opposed to practical methods of solving content problems may account for variations in levels of improvement. Additionally, agenda-setting and power dynamics seem to function as factors in subsequent revision; specifically, students who establish and follow a conversational agenda regarding their essays tend to make more meaningful changes. The results of this research can help instructors to design and facilitate more purposeful conferences.

EDUCATION

NSSE as an Institutional Assessment Tool: Increasing Student Response Rates

Laura Snelson, Angela Ward, Nikole Higgins, David Anderson, & Sara Chapman

Utah Valley University

A 2014 webinar for the National Survey for Student Engagement (NSSE) reported a lack of empirical information regarding the extent to which campus promotional campaigns impacted survey response rates. Anecdotal evidence was reported indicating greater frequency and benefits for response rates. At Utah Valley University (UVU), NSSE has been administered for the past 6 years. Administrators at UVU are interested in using NSSE data to inform leaders at lower-level units

(department, college, and major). To achieve the desired level of student participation and maintain reliable and valid results, the Office of Institutional Research and Information (IRI) set out to evaluate the efficacy of general campus promotional activities designed to increase the level of NSSE response rates. Higher-level response rates at lower-level units may generate reliable and valid results that can accurately impact macro-level policy implications and drive informed decision making at the administrative level. The general campus promotion processes will include an exploratory phase, implementation of intervention (advertisements), and follow-up assessment. First, we will conduct focus groups to evaluate whether the proposed advertising banner's design conveys intended NSSE message, what NSSE is, and the level of student awareness regarding the NSSE survey. Second, it will be redesigned to reflect focus group suggestions. Next, the promotional campaign will include the display of physical and digital banners of different sizes in high-traffic campus locations and the university website during spring term. A survey will be conducted with a random sample of about 10,000 UVU students post-implementation phase. Additionally, interviews and focus groups will be used to evaluate any increase in student awareness. We expect to observe response rates higher than in the past five years. We also anticipate higher campus-wide awareness of the NSSE survey following the intervention.

EDUCATION

The Use of Inquiry-Based Lessons in Teacher Preparation Courses

Jim McCoy & Ray Brooks

Southern Utah University

Instruction in teacher preparation courses can be significantly enriched, enhanced, and expanded by the regular use of inquiry-based learning activities. Inquiry-based learning begins by presenting questions, problems, or real-life scenarios to be resolved. It contrasts significantly with common classroom instructional practices of simply presenting basic facts or portraying a smooth teacher-centered path to knowledge. In the inquiry-based instruction model, the instructor takes on the role

of a facilitator, rather than the dispenser of factual information. At Southern Utah University (SUU), students—the inquirers—identify and research issues and/or questions to develop their knowledge of teacher education–related topics. The inquiry-based learning activities in the block classes at SUU center on problem-based learning issues focusing on learning at the higher levels of Bloom’s taxonomy. The assignments generally focus on small-scale investigations and projects, as well as research. In this presentation, the researcher will present information on the critical elements of inquiry-based learning strategies, the essential procedures to its effective implementation, and student surveys reflecting student attitudes on inquiry-based learning strategies and their effectiveness in developing a meaningful knowledge and skill base in secondary education methodologies.

EDUCATION

Microaggressions, Telomere Length, and a Chance to Bring Social Justice Topics into the Biology Classroom

Patricia Robello, Jonathon C. Marshall, & Leticia Alvarez

Weber State University, University of Utah

Microaggression is a form of subconscious and often unintended racism. However, microaggressions are a continuing reality for people of color, women, and LGBT individuals in our society. They come in many forms and in different environments. We review the most recent literature on microaggressions and studies that look at the detrimental psychological and emotional effects of microaggressions. We also discuss the debate on the physical reality of these effects and the most recent research on the connection between microaggressions and a shortening of chromosomal telomere length. We finish with a call to action to use the research on the impacts of microaggressions and telomere length to bring awareness of issues of social justice into the biology classroom.

EDUCATION

Reducing Test Anxiety via Re-Tests

Dr. John Hill and Brianne Hill

Salt Lake Community College, Penn State University

The researchers followed-up a previous study on reducing test anxiety in which toys were used to reduce test anxiety among college students by way of designed deflection and/or diversion. In the present study, the researchers used the offer of a re-test in an experiment to reduce test anxiety among college students by way of ameliorating anxiety (promised if a student did poorly on the original test/exam).

EDUCATION

The Neglected 'R': Improving Elementary Students' Writing Through iPad Apps

Sue A Womack, MiOk Kang, & Laird Sessions

Utah Valley University

Seeing that writing instruction was neglected despite the mounting evidence of clear deficiencies in student writing, the National Commission on Writing (2003) branded writing skills as the neglected "R." In an effort to give due attention to writing and to improve student writing, one teacher wondered what would bring more clarity and cohesion to students' narratives. Would technology help? In this study, we investigated what would happen when solid elementary school teaching is supplemented by iPad apps. All 5th grade students in one class had excellent instruction in writing, and half of those students also were instructed on particular iPad apps, which they could use as planning and composition tools. The teacher was able to test the effects of iPad app use versus non-use because of the Track A/Track B structure of the school. Over a nine-week period, all students had the same instruction from the teacher. Track B students were introduced to iPad apps that focused on particular elements the teacher had instructed them on, while Track A students did not have use of the iPad apps. This study found that while ALL students' writing improved, several aspects of writing were noticeably improved in the iPad-using group over the

non-use group, as were several affective elements of the classroom. Results will be presented with examples of the children's writing, and children's opinions about writing and the iPad apps offered through their journals and interviews. Opportunity to browse the apps used will also be offered to participants.

EDUCATION

Mentoring a Special-Needs Student Teacher in a Community of Practice: A Success Story

Ann C. Sharp, Mi Ok Kang, & Gary Moser

Utah Valley University

Many teacher education communities represent certain forms of social organization in which the members come together for a joint enterprise, build relationships based on mutual engagement, and keep a shared repertoire of communal resources (routines, sensibilities, artifacts, etc.). Learning occurs not as an individual endeavor but as a social process within which a group of people have shared concerns, problems, and/or topics. Newcomers, such as student teachers, understand and adopt the practices of more experienced members, not by simply mimicking the existing members' practices but by becoming fluent in the socio-cultural practices of the community. This case study examines the collaborative works of a community of practice in which a student teacher who had struggled with challenges such as anxiety, depression, and ADD overcame these barriers and successfully graduated from the School of Education. In this context, this study asks two questions: (a) How were knowledge and experiences organized for the participating student teacher with special needs? and (b) how did the student teacher's participation in the communities of practices influence his actual practice? Retrospective in nature, the study looks back at the phenomenon and asks how by examining the factors in relation to the outcome. The authors took an emic perspective as insiders as we tried to make sense of the data from a "native" point of view. This was possible because not only was the first author a major participant, but he also kept a reflective journal of daily events. We rely on ethnographic observations and interviews for our data collection and qualitative methods for our analysis. The findings of the study raise

implications for educating teacher candidates with special needs in traditional teacher education communities and insist that more emphasis needs to be given to the socio-cultural dimension of student teaching.

EDUCATION

Cultural Awareness Among Elementary Teachers

Amanda Siebert

Utah Valley University

This study explored the extent of cultural diversity awareness of in-service, elementary teachers in the Intermountain region. A group of 55 in-service teachers from the Intermountain region completed the Cultural Diversity Awareness Inventory, which assessed their beliefs about cultural diversity according to the following domains: general cultural awareness, culturally diverse families, cross-cultural communication, assessment, and creating a multicultural environment. Data from the survey were coded for cultural awareness in the domains mentioned. The findings of this study give a snapshot of the cultural awareness that teachers in the Intermountain region possess currently.

EDUCATION

Grant Writing Instruction at the J. Willard Marriott Library, 2002-2015: A Case Study

Peter L. Kraus

University of Utah

In a majority of academic disciplines, grant writing is a skill that is often self-taught or acquired informally by trial and error. Unfortunately, grant writing has received little or no emphasis in traditional instruction in higher education. Grant writing is a critical skill for new and experienced faculty. For many, the prospect and challenge of writing a grant can seem daunting; however, with institutional support and the support of colleagues, this endeavor can be

a meaningful, learned, and rewarding professional experience. Today, as budgets of colleges and universities continue to meet the challenges of the current economy, faculty at all levels are looking to external funding to support research and creative endeavors within their academic fields. Among the institutions that universities and colleges are becoming dependent upon for funding are foundations, which are unique American institutions of philanthropy. Since 2002, the J. Willard Marriott Library has provided grant writing classes for the university community and the general public in the area of foundations and charities as well as instruction to faculty and staff through workshops offered by the Vice President for Research. This talk will present the evolution and development of these classes at the University of Utah.

EDUCATION

Curriculum-Based Model for Effective Involvement of Diverse Families in Mathematics Education

Vessela Ilieva

Utah Valley University

Research has established that family participation in education has significant positive effects on students' academic success. It results in increased student interest, participation, and achievement. Teachers and administrators report that parents of ethnically and linguistically diverse students are less likely to communicate regularly with schools and are less involved and willing to be involved than expected. These parental behaviors are strongly attributed to lack of interest in their children's education. In contrast, first-person accounts of parents report that families of diverse students are invested in their academic progress and success and provide consistent support at home and school. These contradictions in terms of parental participation are especially strong with respect to mathematics education, as some consider mathematics a universal language that is culture free and expected to transcend linguistic and cultural differences. In an era of standard-oriented mathematics education, at-home support (or the lack of such) is often seen as major contributor for students' ability to reach the mathematics standards and progress as expected. This study explored the roots of the

discrepancy between the professed willingness and interest for involvement of families of diverse students and the perceived absence of such involvement in mathematics. Qualitative data were collected from interviewing parents of ethnically and linguistically diverse students. Based on an in-depth data analysis and with support from theory, a curriculum-based model for effective parental involvement in mathematics has been formulated and will be presented.

EDUCATION

STEM Partnership for 21st Century Teaching and Learning

Vessels Ilieva & Elaine Tuft

Utah Valley University

According to the National Math and Science Initiative, 16 of the 30 fastest growing occupations through 2016 will require substantial mathematics and/or science preparation. Nationally, and particularly in Utah, there has been an emphasis on STEM education with the purpose of better preparing K–12 students to enter and succeed in higher education as well as to prepare them for 21st century careers. Teachers who are qualified and knowledgeable about teaching and incorporating STEM in their practice are key to this preparation, especially in elementary schools; however, students in teacher preparation programs do not have sufficient opportunities to explore in depth all aspects of STEM teaching skills and knowledge and are often hesitant to teach STEM-integrated activities to their students. This project is an implementation of a STEM-focused robotics program in elementary schools. Utah Valley University (UVU) students (primarily elementary education majors) are trained and then teach enrichment robotics classes. This project is now in its third round of implementation and is a partnership between UVU's School of Education, neighboring school districts, and a local company Learning Through Robotics. Personnel from Learning Through Robotics train the UVU students how to connect mathematical concepts to the programming and building of functional robots. Using that knowledge, the UVU students teach elementary students how to design and build their own robots able to follow predetermined tasks. The presentation will include information

on the program design, the project collaborations, data from the 10-week cycle implementations, and implications of this form of engaged learning for schools and colleges interested in innovative STEM implementation.

ENGINEERING

USU's Space Dynamics Laboratory: An Unlikely Success

Brian Simons & Douglas Lemon

Utah State University

The Space Dynamics Laboratory (SDL) at Utah State University (USU) has roots in Cold War atmospheric science but has thrived and expanded long after fear of Soviet aggression dissipated. SDL's location in Cache Valley is an unlikely one. It is far from research clusters and industrial centers. It is two hours away from a major airport. Why indeed has SDL been a success in a seemingly random location? This history research is based on work as an historian for USU's Engineering College with the task of archiving early SDL documents and the creation of an institutional history of SDL. SDL's initial success in Cache Valley was made possible when Dr. Larry Cole hired Dr. Doran Baker to create and lead a space engineering research program at USU. The program was awarded its first contract, secured by Dr. Doran Baker, from the U.S. Air Force. A second key factor was when Dr. Farrell Edwards recruited the University of Utah's Upper Air Research Laboratory, led Dr. Kay Baker, to USU. The first group focused on infrared spectroscopy, while Kay's group focused on atmospheric concentration of free electrons. A merger of the two complementary laboratories became SDL. SDL's continued success is due to several factors. SDL has oriented itself primarily as a research institution, rather than a manufacturer, allowing SDL to stay on the cutting edge of technological innovation. SDL has been willing to take risks (and learn from failures), leading to diversification in its effort to meet current sponsor needs. As part of USU, SDL has fostered an integrative approach to student education. Students receive hands-on application of what they are learning in class while working or interning for SDL. These students go on to have successful careers; some remain at SDL. Innovation, diversification, and student interaction are keys to the success of SDL.

ENGINEERING

Hybrid Wind and Solar Electric Power System

Doran Baker & Gene Ware

Utah State University

Students at Utah State University systems engineered a renewable energy electric hybrid. The approach is to integrate electric power from a three-panel solar array and from a horizontal axis wind turbine (HAWT). Typically, the wind is harvested for about eight hours after midnight, and the solar irradiance for about six to eight hours during daylight. Electric energy storage uses chemical batteries. The 300-watt relatively low-power system is intended primarily for education and demonstration purposes. A Thunderbolt Magnum solar array comprised of photovoltaic (PV) cells, a DC maximum power position tracker (MPPT), and a dispersive load were used for the electric power system. An AC-DC inverter and DL-300 charge controller prepared the electric energy for battery storage. A Campbell Scientific CR1000 Data Logger is used for system control, output data plus metadata storage, and system monitoring. The base station, comprised of a Dell computer with dual monitors and software, provides remote access to a web server. Students programmed the computer, the data logger, and a GUI for performance and output power display along with meteorological data.

ENGINEERING

Sun and Aureole Measurements (SAM) Tracking Control

Connor George, Jeanne Munk, Gene Ware, & Doran Baker

Utah State University

The Sun and Aureole Measurement (SAM) system is a ground-based atmospheric particle measurement system that images and analyzes the solar disk and its aureole. To accomplish this analysis, it is necessary to accurately track the solar disk. The images taken are processed using the Canny edge-detection algorithm along with the Hough parametric transform to determine the center of the solar disk. These data are used to position a tracking mount so that the SAM accurately focuses on the sun. This algorithm is robust enough to function even when the sun is

obscured by clouds and other obstructions. The characteristics and accuracy of this Hough transformed-based control system are discussed, and application examples are presented.

ENGINEERING

Spaghetti Bridge

Cody Hatch

Snow College

This year Snow College had its first Engineering Week. As one of the activities of the week, we were challenged to build a bridge out of spaghetti and wood glue. The goal was to build a bridge with the highest efficiency of load to mass ratio. I did experiments to find out how spaghetti acted in certain conditions. I applied what I had learned in my Statics class here at Snow College to better understand what was happening with the forces in the bridge and how they were distributed throughout the beams on the bridge. I then applied what I learned in my Strength of Materials class to find the failure mode of the bridge and how to best avoid it. While I was building the bridge, the design evolved and needed to be adjusted to allow the pieces to fit. I then tested it to see how well my design held a load. After loading it to failure, I analyzed the bridge and tried to figure out where it failed. I then tried to find out why it failed where it failed. After knowing where and why it failed, I proposed a new design that would fix the problem.

EXERCISE SCIENCE AND OUTDOOR RECREATION

Using the 2014 Olympic Winter Games as a Catalyst for Physical Activity

James Bemel

Utah Valley University

The bid for the London 2012 Olympic Summer Games included statements related to the potential impact of the Games upon physical activity levels of U.K. residents. Additional studies suggest possible impacts upon residents of non-host countries as well; however, the literature is non-conclusive regarding this potential impact.

HealthyPeople 2020 includes goals and objectives related to increasing physical activity among Americans and therefore, if the Games could potentially increase physical activity, this effect must be better understood. The purposes of this study were to (1) determine whether the Sochi 2014 Olympic Winter Games resulted in a significant increase in physical activity among university students in Utah, (2) determine whether factors other than watching the Olympic Winter Games may influence any increases in physical activity, and (3) provide participants a mode of sharing their ideas and methods of utilizing the Games to increase physical activity. Participants were randomly selected and completed pre- and post-Games surveys inquiring about levels of physical activity, Olympic Games viewing behaviors, perceived and actual effects of viewing the Olympic Games, and methods of utilizing the Games to promote physical activity. A total of 395 students completed the pre- and post-Games surveys. One area of physical activity (muscle-strengthening activities) significantly increased between the pre- and post-Games surveys and the other three areas measured (moderate-intensity aerobic activity, vigorous-intensity aerobic activity, and body mass index) did not result in significant differences. Twenty percent of those who reported increased physical activity levels indicated that the increase was due to no reason other than watching the Olympic Games. While results indicate a limited potential for the Olympic Winter Games to increase physical activity, participants' suggestions for utilizing the Games to promote physical activity may be utilized to positively impact Americans' exercise habits during the Olympic Games.

EXERCISE SCIENCE AND OUTDOOR RECREATION

Exercise Intervention on Obstructive Sleep Apnea Patients

L. Nathan Thomas

Salt Lake Community College

The purpose of this pilot study was to evaluate the effectiveness of clinician referral on EIM programs housed within the clinic of the referring physician and re-confirm lifestyle intervention may reduce symptoms of OSA and increase quality of life (QOL). Eight patients were invited to join the pilot study from their ENT physician through a prescription. Eight OSA patients will be recruited to act as a control

group and participate in pre- and post-surveys. All patient data are subject to HIPAA guidelines and stipulations. Each potential participant was referred by a physician. The physician reviewed patient health and discussed all medical history, medications, and contraindications and a release to participate in activity. Patients were in stable condition to become a participant. Survey topics included daytime sleepiness, QOL, mood stability, and leisure activity participation. An OSA severity score was used. A cardiometabolic profile was provided by supporting physician (consists of a lipid panel, glucose, inflammation markers) and blood pressure, anthropometry, body composition, cardiorespiratory fitness, and strength (muscular endurance) were assessed. The study was designed to be a 12-week intervention with a 2 visit per week routine for a total of 24 visits. Each visit took place at the Ear, Nose, and Throat Center in Draper, Utah. If the OSA participant was on medication or a CPAP, they continued with treatment and supplemented the intervention along with clinical treatments. Intervention consisted of a personal cardiorespiratory exercise and strength-training routine based initial health and fitness assessments. Individual interventions were created based on ACSM guidelines and physician guidance. The exercise prescription was a low to moderate intensity following a modest progressive loading theory. On visits 5 and 15, a registered dietician evaluated nutrition habits individually with each participant to help them make small manageable changes to diet and track progress with nutrition goals. All activity was recorded. Statistics will be presented. All patients demonstrated improvement in management of disease. The implications of this study are the implementation of a working relationship between clinicians and qualified fitness experts in the collaboration of lifestyle intervention on increasing QOL and decreasing disease symptoms. This pilot study served as a base model for additional possible research and data collection for justification in the implementation of EIM interventions within clinical settings.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

The Influence of the Black Plague in Europe

David Ritchie

Utah State University

Un examen de la peste en Médiéval France compromettant les réactions cultural, les symptômes, et le traitements. Cet article démontra le massif impact de la Peste sur les peuple français et leur pratique de la médecine.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

Unveiling Sophia de Mello Breyner Andresen's Children's Literature

Serena Johnson

Brigham Young University

I undertook my research in an attempt to draw the attention of the English-speaking academic community to a body of undervalued literature. With this goal in mind, I translated three chapter-length children's books written by the famous Portuguese poet Sophia de Mello Breyner Andresen: 1) *A menina do mar* [The Sea Girl], 2) *A noite de Natal* [On Christmas Night], and 3) *A fada Oriana* [The Fairy Oriana]. Several volumes of Andresen's poetry can be found in translation. For the most part, however, her children's literature has been sadly overlooked by the scholarly community in the United States. Yet books such as *A menina do mar* are currently part of Portugal's public school curriculum. When I traveled to Lisbon to conduct research in the National Library, I took a detour and walked into Portugal's oldest bookshop, the Livraria Bertrand in the Chiado district. I made my way through the tomes to the back room filled with juvenile literature. Sophia's books held the place of honor, next to classics like *The Little Prince* in translation. Her children's books, and especially the three I chose to translate, are overlooked gems of children's literature. Finally, I address the question of children's literature being treated as literature. To what extent does the dismissal of Andresen's

children's books represent a larger pattern? Classics of children's literature are teaching the rising generation what to think—what to be. Surely, then, they are deserving of our attention.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

Collaboration and Performance in the Pessoa/Queiroz Love Letters

Todd Mack

Southern Utah University

Fernando Pessoa's heteronymic project is surely one of the most important creative acts of the 20th century and perhaps in all of history. Although it is common to think of Pessoa as a tormented and solitary genius, this article examines questions of collaboration and performance in the love letters exchanged between Pessoa and Ofélia Queiroz. For decades, criticism regarding this correspondence focused almost exclusively on Pessoa's psychological state and on the heteronymic games he played with (or jokes he played on) Queiroz. In this article, based on theories of play, performance, and collaboration, I show Queiroz's willingness and ability as a collaborator in the Pessoaan artistic creation from the beginning of the relationship in 1921—when Pessoa confesses his love to her in an improvised and spontaneous scene from Hamlet—until the end of their relationship in 1931.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

How to Improve L2 Students' Oral Proficiency

Lucia Taylor

Dixie State University

What can we do to improve our students' oral proficiency abilities? The development and assessment of oral proficiency have received considerable attention in second language acquisition and teaching ever since Communicative Language Teaching became the dominant approach in the late 1970s and 1980s. Both ACTFL and the Council of

Europe have proposed descriptors for different levels of proficiency as well as assessment methods that can be applied across languages. How can we help our students in class to improve the oral proficiency? I think having a knowledge of these two different frameworks can help our methods and techniques when teaching a foreign language class. In this presentation I will summarize the descriptors of these frameworks and suggest different strategies we can use to help our students while in class.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

Attitudinal Shifts in Student Perceptions of the Personal and Professional Value of an Academic Service-Learning Course in the Humanities: An Exploratory Study

Kimberli M Lawson

Utah Valley University

What do students learn from Academic Service-Learning? And how are they assessing the value of Academic Service-Learning to the various components of their own education? How do they rate their development in various learning categories? There are many types of learning that are valued in higher education, and scholars and educators do not always agree on which types of learning are most valuable, or even how various categories and modes of learning are interconnected. This exploratory study is a small first step in understanding and improving my own instruction. My purpose in employing a community engaged, Academic Service-Learning project for the General Education Humanities course is to dispel what I consider to be a false, limiting belief that art remains unconnected to real life. To facilitate the exploration of the idea that we interact with, and react to, art frequently throughout our day-to-day experiences, I pose the following research question to students: "How can art transform a local community space?" I track quantifiable shifts in students' belief systems in six categories from the beginning of the semester to the end of their project through the collection of survey data. I believe that the local community space is not the only thing that can be potentially transformed through this engaged learning project. Students, in some small way, are also transformed in their belief in the power or art to

shape a physical space, their belief in their ability to make a difference in their community, and their understanding of how to organize and execute a meaningful project.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

The Challenge of Pluralism: Metaphysics and General Education

Harrison Kleiner

Utah State University

In this paper, I will explore the challenges public and secular private institutions of higher education face when formulating and defending general education programs. I will argue that a necessary condition for having a coherent and deep understanding of liberal education requires reaching some consensus on the metaphysics of man. I will begin by exploring the claim in Newman's *Idea of a University* that only Catholic universities can be real universities. This is typically dismissed as a bit of sectarian chest thumping about Catholic superiority. But my reading is that Newman is making the claim that a coherent curriculum requires an adequate philosophical anthropology and metaphysics. In short, one cannot sort out the proper ends of education without first having a settled view on the proper ends of man. General education committees at secular institutions, public and private, are either unable or unwilling to engage in these metaphysical questions. I will argue that this results in incoherent general education programs that focus not on content but on "learning outcomes"-based sets of skills, most notably "critical thinking and communication skills." These "learning outcomes" are typically defended with purely vocational arguments. While I do not dispute that those skills are useful, the reduction of the purpose of a liberal education to useful skills is fundamentally opposed to the more traditional view that liberal education is intrinsically valuable rather than only instrumentally so. My claim will be that this intrinsic value can only be recognized from certain metaphysical positions concerning the nature of man and human goods. I will conclude by looking at the prospects for developing a consensus on these metaphysical questions in a public university and, with that consensus, how we might communicate the value of liberal

education, and especially the humanities, in an environment generally hostile to liberal education.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

Toward a Phenomenology of the Wilderness Experience

Gregory Esplin

Utah State University

This paper seeks to explore the wilderness experience in pure descriptive terms. Informed by phenomenology, the focus of this inquiry shall be limited to how the human being experiences wilderness. For the moment, I shall “bracket” ethical questions regarding whether human beings have a moral responsibility to preserve wilderness. Instead, a narrower question will be explored: do individuals relate to themselves differently in the backcountry? What does wilderness offer that one cannot find in other recreational activities? Because wilderness inserts a fundamental gap between one’s self and other individuals by way of the forces of isolation as well as the dangers of the outdoors, which can never be entirely mastered, in such experiences I argue that we can come to experience ourselves in a unique way, not as a Subject that can dominate and order the world, as Heidegger criticizes as the “danger” of “Technological Thinking,” but as immersed in a loss of self that can happen in pure activity, when one is thoroughly engaged with the world, embedded within nature, rather than standing off against it.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

Breaking Dichotomies: Agency and Continuity in Lars von Trier’s *Breaking the Waves*

Whitney Borup

University of Utah

Many film scholars have argued about the meaning of Lars von Trier’s enigmatic and dense film, *Breaking the Waves* (1996). Largely, the

argument centers on the question of agency. Critics debate whether the protagonist of the film, Bess, controls the terms of her own sexual transgressions or whether she merely obeys a patriarchal system that conflates men with the divine. While the conversation about whether or not Bess has the capacity to craft her own morality is essential to understanding her sacrifice at the end of the film, I believe these critics ignore an important aspect of Bess's identity. Bess frequently communicates with God. Switching between her high, feminine voice and a deeper, more masculine voice, Bess answers her own questions to God as God. Communicating with the divine through her own body, mouth, and voice, Bess becomes God. As though a part of the Trinity—or multiple beings in one—Bess and God share one purpose, and therefore one will. So rather than discuss how Bess acts within, with, or against patriarchy, my paper argues that Bess, as God, recreates the system through her sexual transgressions. Through Bess's sexual and mortal sacrifice, she models a new system of power based on continuity rather than clearly marked borders between male and female, self and other, and the divine and the sacred. I use George Bataille's observations on continuity, the sublime, violence, and sacrifice to argue that *Breaking the Waves* represents gender and divinity as porous, ambiguous concepts.

LETTERS—LITERATURE

Transnational: An Identity Thrust upon Chinese Immigrants in Ha Jin's *A Good Fall*

Soran Kurdi

Weber State University

How does the concept of transnationalism fit within the framework of immigrant identity? Can immigrants live their lives in one place, according to one set of cultural norms, in countries with impermeable national borders? This paper, through analyzing Ha Jin's *A Good Fall*, examines the lives of the Chinese immigrants who have entered the United States over the last three decades of the twentieth century and want to assimilate into the American mainstream. In particular, the paper argues those aspects of transnationalism that make these immigrants not fully assimilate into the American mainstream. It highlights how the process of seeking a new identity, while retaining

old cultural traditions, forces the Chinese immigrants to assume their transnational identity.

LETTERS—LITERATURE

Byronic Bad Boys

Elizabeth Robison

Weber State University

Considered by many to be the first modern cultural celebrity, George Gordon, Lord Byron lived an ostentatiously aristocratic life, complete with overwhelming debt, a sensational list of lovers, and self-appointed permanent exile. This British bad boy of the 19th century continues to wield an enormous influence in our own average 21st-century lives through his literary creation, a direct reflection of himself and his legacy, the Byronic Hero. Byron's spectre reappears throughout literature and pop-culture: as the continually tortured and brooding character, Heathcliff, in Emily Brontë's *Wuthering Heights* (1847), the evasive and mysterious Mr. Rochester in Charlotte Brontë's *Jane Eyre* (1847), the moody, antisocial, sex-symbol James Dean (*A Rebel Without a Cause*), and the violent, cynical loner Wolverine from Marvel's X-Men comics and films. It is the very Byronic nature of such characters, particularly their intrigue and the admiration and envy they excite in readers and viewers, that accounts for their enduring popularity. Lord Byron was the source of fascination during his own era for the same reason that his 21st-century Byronic descendants are for us today: the Byronic Hero is an exaggerated version of ourselves—an exaggeration of our history, deficiencies, and of ideals.

LETTERS—LITERATURE

The Ethics of Holden's Binary Dystopia in *The Catcher in the Rye*

Megan Toone

Brigham Young University

The Catcher in the Rye centers on the detrimentally false binaries used and amplified by Holden as he grapples with the dystopian worlds

existing both within and outside his own head. Ultimately, the novel invites ethical analysis of Holden's flawed binaries, of the cynicism with which he meets a world gone wrong, and of the viability and potential consequences of his perceived responsibilities. Traditional readings of Holden's perceptions argue for their straightforward nature; thus, critics have generally seen Holden's innocence as transcendent or cynical. But all such readings fail to acknowledge the complexity of Holden's world. An ethical analysis of the novel underscores Holden's realistic and mixed nature: the sensitivity and fundamental goodness that lift him, the rigid black-and-white worldview that is his potential downfall. On the one hand, Holden's nature enables him to accurately judge crucial elements of others' characters; on the other, it blinds him to non-categorical complexities and leads to his making false judgments about his fellows and the larger world. Thus, an ethical reading of Holden's character emphasizes that a binary-centered paradigm blocks truth and leads to stagnation or chaos through intensifying one's perceptions of a dystopic world.

LETTERS—LITERATURE

Influenza, Heritage, and Magical Realism in Katherine Anne Porter's *Pale Horse, Pale Rider*

Katherine Nelson

Brigham Young University

Despite the devastating scope of the Spanish Influenza Pandemic of 1918, curiously few references to the flu exist in literature. Katherine Anne Porter offered one of modernism's only extensive fictional treatments of the pandemic in her short novel *Pale Horse, Pale Rider* decades after her own near-death encounter with the flu. Porter was able to give voice to an experience that had traumatized others into silence by drawing on an early form of magical realism. Magical realism's ghosts—everyday presences rather than otherworldly beings to be feared—are of particular relevance to *Pale Horse, Pale Rider*, since ghosts “haunt” Porter's semi-autobiographical Miranda throughout the story, acting as correctives to Miranda's (and Porter's) desire to isolate herself from the familial and regional heritage that burdens her with unwanted and often conflicting ideologies. Ultimately, in using magical realism to explore her sense of self and to articulate the alienating effects of her near-death experience, Porter is

able to embrace her complicated heritage and her fractured past, reclaiming interconnectedness while maintaining her individuality.

PHYSICAL SCIENCES

Weak Measurements of Spin to Quantify the Uncertainty of the Heisenberg Uncertainty Relation

Jacob J. Collings & Jean-Francois S. Van Huele

Brigham Young University

We revisit the significance of the Heisenberg Uncertainty Relation (HUR) as it applies to two very different situations: one pertaining to preparation uncertainty, the principle that one cannot prepare a quantum system such that two incompatible observables are arbitrarily well-defined for it, the other pertaining to measurement uncertainty, the principle that the measurement with a certain degree of accuracy of one observable disturbs the measurement of another observable incompatible with the first, be it jointly or sequentially performed with the first. We explore the fundamental differences between these uncertainties and their impact upon the HUR. We review recent experiments showing evidence for a violation of the measurement uncertainty as well as proposed reformulations of this relation. We illustrate this point with an explicit calculation of uncertainty in a spin measurement with varying degrees of strength.

PHYSICAL SCIENCES

Correlation of OH and O₂ Airglow in the Night-Time Mesosphere

Jonathan Price

Utah State University

Correlation work is being done to determine the relation between the energy emitted by hydroxyl (OH) and that of molecular oxygen (O₂) in the mesosphere of the Earth. The data used in the correlation have been collected by the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument aboard NASA's Thermosphere Ionosphere Mesosphere Energetics and Dynamics

(TIMED) satellite over the last 13 years. The data are processed at Utah State University (USU) by the SABER team. These correlations provide useful information applied to the global modeling of the mesospheric region over a full solar cycle (>11 years).

PHYSICAL SCIENCES

Centrality Measures of Graphs Utilizing Continuous Walks in Hilbert Space

Jarod P. Benowitz

Utah State University

Centrality is most commonly thought of as a measure in which we assign a ranking of the vertices from most important to least important. The importance of a vertex is relative to the underlying process being carried out on the network. This is why there is a diverse amount of centrality measures addressing many such processes. We propose a measure that assigns a ranking in which interference is a property of the underlying process being carried out on the network.

PHYSICAL SCIENCES

Inexpensive and Ecofriendly Synthesis of Porphyrin Derivatives for Incorporation into Dye-Sensitized Solar Cells

Ivy Carroll, Kristine Booth, Moriah Dalton, Appolonia Pennman, Brandon J Burnett

Snow College

The production of inexpensive and efficient sources of alternative energy has become more important because of increased pressure to reduce carbon emissions and fossil fuel consumption. One source of alternative energy that is promising is solar energy through the use of dye-sensitized solar cells (DSSCs). Solar energy, however, is still relatively expensive, and the processing to create solar cells is often not environmentally friendly. Within DSSCs, the most expensive component is in synthesizing the pigment itself. These are often challenging and expensive to synthesize, because of the large amounts

of environmentally damaging solvent required to run the reactions and purify the product. Herein we propose a new synthetic approach to synthesizing porphyrin derivative pigments through a liquid-assisted grinding (LAG) approach. In LAG, no solvent is required, allowing for cheaper, more environmentally friendly porphyrins for solar cell use.

PHYSICAL SCIENCES

High-Sensitivity Spot Tests for the Detection of Diphenhydramine

Melissa Warren & Ed Walker

Weber State University

The detection of diphenhydramine (Benadryl) in trace amounts was found using prepackaged swabs and a cobalt(II) thiocyanate/water reagent. A bright blue color change on the swab indicates the presence of diphenhydramine. The detection limit for diphenhydramine using a water and cobalt(II) thiocyanate solution is a 0.1% diphenhydramine solution. Any lower detection is subject to false positives of the reagent reacting with the adhesive on the swabs.

PHYSICAL SCIENCES

Patterning Supported Lipid Bilayers with Magnetic Tweezers

Tyler Argyle, Travis Bulloch, Madeline Gleave Parson, & Chris Monson

Southern Utah University

Lipid bilayers are essential to living cells. In any living cell, it is the lipid bilayer that separates the fluid inside the cell (the cytoplasm) from the fluid surrounding the cell. The arrangement of components within the cell membrane is also extremely important, particularly in cell communications. The ability to generate specific patterns within a bilayer could see many applications in biology and medicine. Supported lipid bilayers are a convenient platform on which to study membrane patterning. Previous work with supported lipid bilayers has explored several methods by which various grid-based patterns can be

formed in the cell membrane. None of these, however, provide a way to generate the type of circular pattern that would be required for many types of cell synapses. We formed a supported lipid bilayer containing a small amount of fluorescein-labeled lipids. We then introduced superparamagnetic beads coated with anti-fluorescein antibodies, causing the aggregation of fluorescein-labeled lipids into a circular pattern under each bead. The beads were retracted with a magnet, and pattern formation was confirmed using a fluorescence microscope.

PHYSICAL SCIENCES

Validation of Metal Chelation by FTIR Spectroscopy

Monika Miller, Lani McKinnon, & Edward B Walker

Weber State University

Nutritionally important minerals are more readily absorbed by living systems when they are combined with organic acids. These combined metal–organic acid complexes are called chelate metals or chelates. The synthetic processes utilized to prepare these mineral chelates add significant cost to the final product. Occasionally, manufacturers sell cheaper dry blends of unreacted minerals and organic acids to gain an unfair competitive advantage in the marketplace. There are few if any reliable methods for reliable measurement of the extent of chelation between metals and organic acids. We report our successful application of Fourier-transform Infrared Spectroscopy (FTIR) for the quantitative determination of chelation in solid samples of mineral chelates.

PHYSICAL SCIENCES

Phosphatidylserine-Copper (II) Binding Can Result in Flipping

Conner Winegar, Chris Reynolds, Mike Trujillo, Tyler Scholes, & Christopher Monson

Southern Utah University

Phosphatidylserine (PS) is a phospholipid present in many eukaryotic cells that reversibly binds to copper (II) ions in basic conditions with an attomolar binding affinity. In acidic solution, the copper is released.

Previous work has suggested that PS can “flip” from one leaflet of a bilayer to another when it binds copper and that when it flips it brings the copper with it to the other leaflet. If this actually occurs, it could be an important copper ion expulsion method for cells and might also contribute to Wilson’s disease. To test this hypothesis, we performed two types of experiments. First, we tagged a PS bilayer with fluorophores and monitored the fluorescence as copper ions were introduced (copper binding to PS quenches fluorophores) and then selectively removed from the top bilayer by EDTA. Second, we encapsulated orcinol inside of vesicles containing PS and then added copper to the outside of the vesicles. Orcinol undergoes a copper-catalyzed reaction that causes it to go from clear to colored, allowing the presence of copper inside the vesicle to be measured by monitoring the color change. In both cases, our results support the hypothesis that the PS–copper complex can flip from one leaflet to another.

PHYSICAL SCIENCES

Determination of Quercetin and Phenols in Dark Chocolate

Brad Draper, Hannah Firth, & Ed Walker

Weber State University

It is widely known that cacao beans are one of the most abundant sources of naturally occurring flavonoids on earth; however, chocolate products contain only a small percentage of the original flavonoids present in cacao beans, indicating that up to 95% of these flavonoids are lost during the manufacturing of chocolate. No one has identified the specific events or steps in chocolate preparation that destroy these flavonoids. We have measured the concentrations of a variety of nutritionally beneficial flavonoids at each step of the chocolate manufacturing process to identify the related extent of flavonoid losses. Following multiple-step extractions and sample preparations, we utilized chemical techniques of TLC, UV/VIS spectroscopy, HPLC, and organoleptic testing to measure the levels of catechins and proanthocyanidins at each step of the chocolate-making process.

PHYSICAL SCIENCES

How Trees Are Grown and Counted

Chin-yah Yeh

Utah Valley University

Counting trees and generating tree structures are part of the same scheme. This scheme can be used to generate chemical structures and thereupon build a chemical database. Counting trees is counting the terms in Cayley's formula $\prod_{i=1}^{\infty} (1 - X^i)^{-bi}$. We justify the formula via the process of building rooted trees and demonstrate that this counting formula also supports a method to generate tree structures. Root-free trees are constructed by combining rooted trees through the use of dissimilarity characteristic theorem, an extended form of the Euler characteristic theorem. Trees of limited branching are then discussed.

POSTERS

Antibiotic Production Screening of Actinomycetes Grown on Media of Differing Nutrient Concentrations

Trevor Annis & Michele Culumber

Weber State University

Actinomycetes are bacteria that are found ubiquitously in soil. They produce chemicals that give soil its distinct earthy smell and are known for their capability to produce antibiotics. Antibiotics have obvious clinical importance, but they also help the bacteria in their competition for limited resources in their normal ecological environments. In this ongoing research project, we hypothesize that manipulation of growth media for actinomycetes will have an effect on the quantity and type of antibiotic produced. We are investigating the effects of media low- and high-nutrient concentration and differing concentrations of sulfur and nitrogen on the antibiotic activity of actinomycetes. We suspect that oligotrophic conditions will simulate the natural competition for resources and will induce the bacteria to produce greater quantities of antibiotics.

POSTERS

Population Genetics and Paternity of Tent Caterpillars (*Malacosoma californicum*) in Southern Utah

Stacy Craft, Emily Taylor, Alex Montoya, & Laurie Mauger

Southern Utah University

Understanding the spatial genetic structure and population genetics of pest species is important in the management of these species. These tools allow scientists and managing authorities to identify genetically distinct populations and gene flow between areas. Tent caterpillars (*Malacosoma californicum*) are considered a pest species in southern Utah. They are known to completely defoliate trees and portions of forests. Tents caterpillars are found on two host species in southern Utah, cottonwood and willow trees. Understanding genetic linkages and paternity patterns in tent caterpillar populations could help to manage this pest species. Tent caterpillars were collected from both host species in and around Hurricane, Utah, in spring 2013. We amplified 8 microsatellite loci at multiple nest sites on a single tree and between multiple trees to determine paternity within a nest, relatedness between nests on a single tree, and gene flow between trees. This study will help manage tent caterpillar populations in southern Utah by providing neutral genetic diversity and the number of distinct populations of tent caterpillars.

POSTERS

Why Do (and Don't) Women Go into STEM? A Mixed-Methods Approach

Ian Peacock & Benjamin Gibbs

Brigham Young University

Recent scholarship scrutinizing the gender wage disparity has placed an emphasis on understanding the different fields of study that women and men choose before market entry. In particular, there is a broad literature observing and attempting to explain the scarcity of women in science, technology, engineering, math (STEM), and other traditionally male majors. The majority of these theories and studies have focused on the reasons for which women do not enter male-dominated disciplines, in essence, raising the question “why don’t women make the same choices

about field of study and occupations that men do?” Yet there is a lack of empirical investigation and theory exploring why the few women who go into STEM and other masculine majors do so. Thus, we pose and help to answer the question “why do women enter and persist in disciplines where they are minorities?” We surveyed over 3,000 students and conducted over 50 interviews on a conservative university campus with a notably low female-to-male ratio of STEM majors. Among our many findings, our research reveals that having social ties into these traditionally male majors helps women enter and persist. A number of other demographic factors such as race, political ideology and activity, and standardized test scores also matter for predicting who does and does not enter and persist in a STEM major.

POSTERS

Nitrogen Nutrition Impact on Incidence of *Rhizoctonia* Infection of *Agrostis stolonifera*

Beth Black, Bryam G. Hopkins, & Bradley D. Geary
Brigham Young University

Creeping bentgrass (*Agrostis stolonifera* L.) is tolerant of short mowing and high traffic, but these conditions increase pathogen susceptibility. A prevalent disease on bentgrass golf course greens and tee boxes is Brown Patch (*Rhizoctonia solani*). One potential component of integrated pathogen management is correct nitrogen (N) fertilization. Bentgrass was grown in a chamber hydroponically at deficient, optimum, and excessive levels of N (2.5, 10, and 80 mM) with or without *Rhizoctonia* inoculation and grown for 56 d. Not surprisingly, increasing solution N resulted in increased shoot and decreasing root biomass. *Rhizoctonia* inoculation did not appear to dramatically impact biomass; however, infection resulted in near-total necrosis of all tissues at the low rate of N for inoculated plants, but plants at higher N rates and those not inoculated were healthy. The project will be concluded following another study with *Rhizoctonia* and PCR analysis of the roots and crowns from both studies.

SOCIAL SCIENCE

Are You Actually Reading These Maps: A Critical Analysis of Federal Public Land Agencies and Their Practices

Giancarlo Panagia

Westminster College

This paper sets to start a new methodology to address federal agencies' determinations of public interest and equal value during the negotiation of federal land swaps. By using and interpreting the maps of both the offered and elected lands, the federal agency involved in the exchange transaction should be required to fulfill the dictates of the Federal Land Policy Management Act of 1976. After its passage in 1976, FLPMA provided a uniform set of procedures for federal agencies. The unified procedure requires that federal agencies complete a land exchange as long as the agency's Secretary determines that the transaction will benefit the public interest. While many federal statutes and regulations refer to the "public interest," none of them define the term. More importantly, FLPMA still requires that the lands be of equal value. Presently, the use of maps to evaluate the location and the value of the offered and selected lands has not become practice of federal judges that hear challenges to agencies' administrative decision, leaving the final word to the BLM's and Forest Service's discretion.

SOCIAL SCIENCE

Anne Teresa de Keersmaecker's 'Violin Phase' from a Jungian Perspective

Jon Thomas

Utah Valley University

Simple swipes of feet progress into phrases that swirl sand into a mandala; this transition in movement creates an illusion of a timeless dream in Anne Teresa de Keersmaecker's Violin Phase. It could be said that whoever participates in de Keersmaecker's piece enters a trance that does not end until the final abrupt vocal breath. From the Sufi Whirlers performing the Sema to the Pullava and priestesses performing the Serpent Ritual, the body has been used as a medium for entering a

liminal state since the beginning. It is this universal trance or liminal state achieved with the body that takes individuals to the collective human experience inherent in every individual regardless of time and location. Rituals, such as the physical creation of a mandala for example, are exercises that allow for persons to explore the “symbolic life” by “[making] their new vows or their meditations” (Jung, Carl). Archetypes, rituals, dreams, and collective universal subconscious findings were at the heart of exploration for Dr. Carl Jung’s theories in the early twentieth century. He argues that dreams and other manifestations of the unconscious “reveal to the dreamer hidden factors of [the dreamer’s] personality” and that “there must be a thorough-going, conscious assimilation of unconscious contents” (Jung, C.G.). Jung emphasized the power of the arts, including dance, to help in this uncovering and assimilating of other manifestations of the unconscious when he remarked “the creative process has feminine quality, and the creative work arises from unconscious depths” (Hayes). Jungianism will help inform a discussion on dance, on how ritual is conceived, and on how an analysis of Violin Phase reveals the power of ritual for any participant. A critical analysis of Violin Phase by Anne Teresa de Keersmaecker from a Jungian perspective will reveal the power of ritual for the participant.

SOCIAL SCIENCE

Eugenics and the Early History of U.S. Sociology

Andrew Van Alstyne

Southern Utah University

This paper argues that the development of U.S. sociology in the late 19th and, especially, the early 20th century uncritically embraced the eugenics movement. Through an examination of early sociology journals, most notably the *American Journal of Sociology*, as well as sociological and eugenicist conference proceedings, I show that a heavily racialized approach to eugenics was a legitimate, though not central, component of early sociology. Eugenics proposed “scientific” interventions to improve populations. These interventions involved positive (increasing the numbers of desirable peoples) and negative (decreasing the numbers of undesirable populations) approaches. Eugenics had widespread support across the U.S. from everyday citizens, policy makers, and academics. It was only in the post-WWII era, as the world saw the full horrors of Nazism, that eugenics lost its

social legitimacy. While U.S. eugenics saw no substantive moves towards euthanasia, there was a heavily racialized legacy of involuntary sterilizations. Analyzing sociology's embrace of eugenics brings to light an often-ignored component of the discipline's early history and shows that what we think of today as the classic sociological canon is intentionally selective. While there are many reasons for this selectivity, I argue that it is important to acknowledge the negative dimensions of the discipline's roots. Furthermore, the connections between progressive activists, social scientists, and the eugenics movement demonstrates that scientifically objective approaches to social improvement can be deeply flawed and produce horrific outcomes.

SOCIAL SCIENCE

Sex Guilt and Religion: Differences between Baptists, Catholics, and Latter-day Saints (Mormons) in Experiences of Premarital Sex Guilt

Mark O. Bigler, Karen Beale, & Elizabeth Maynard

Weber State University

The hook-up culture common at many colleges and universities presents particular problems for religious students. For some, their faith and their desire to remain sexually abstinent becomes more salient. For others, college becomes a time of sexual exploration, and students feel little internal guilt. A third group—the conflicted sexually active—likely experiences significant cognitive dissonance between their religious beliefs and their sexual behaviors, thus producing high levels of sex guilt. This presentation reports preliminary findings from a study of 750 college students from three different institutions that are predominantly Baptist, Catholic, and LDS (Mormon). This study tests the hypothesis that sexually active college students who have fundamentalist Christian beliefs (conflicted sexually active) have higher levels of sex guilt than those with fundamentalist beliefs who abstain from sexual activity (committed virgins) and those who are sexually active who do not have strong religious beliefs. Drawing subjects from institutions that are predominantly Baptist, predominantly Catholic, and predominantly LDS allows for comparison of levels of sex guilt between students from three very

different religious backgrounds. Comparative results will also be presented.

SOCIAL SCIENCE

Retention and Disaffiliation among Latter-Day Saints in Utah and the Intermountain West

Rick Phillips

University of North Florida

Sociologists have theorized about how new technology and increasing religious pluralism impact homogenous religious subcultures. This research examines how the internet and patterns of immigration and migration have affected membership retention in the Church of Jesus Christ of Latter-day Saints (the LDS, or Mormon Church) in Utah and the Rocky Mountain states. Previous research has shown that defections from Mormonism in Utah and the Intermountain West are more common now than a decade ago; however, other studies show that rates of religious activity (e.g., church attendance, tithe paying) among Mormons in this region are very high by national standards. This research explains the countervailing patterns of rising disaffection and robust religiosity by demonstrating that new technology and increasing religious pluralism have altered Utah's religious climate. In previous generations, even completely inactive Latter-day Saints still self-identified as members of the LDS Church; however, in this new religious climate, the church's least active members are choosing to sever ties with Mormonism altogether and are increasingly likely to describe themselves to survey researchers as secular people with no religious affiliation. The departure of the church's least-committed members raises the mean religiosity of the Latter-day Saints who remain, accounting for very high levels of religious activity among self-identified Mormons in the Intermountain West.

SOCIAL SCIENCE

Divine Fascism and Laws of War in our Metaphysical World

Shadman Bashir

Dixie State University

This paper discusses questions such as what is the logic behind the idea of divine fascism. It provides a very brief analysis of the relationship of political doctrines and the laws of war within a world that is being pushed towards a metaphysical existence. A further consideration is, what has metaphysics got to do with the laws of war? Are organic and inorganic entities compatible with each other in the context of the present global security situation? Are the victories in military conflicts and wars less important than the narrative wars, in the context of the contemporary international scenario, and is it because of the relativity of time and space? If this is true, then it may be due to the ever-increasing presence of the divine and the inorganic within the narratives. The monolith and the tree comparison in the context of Abrahamic Religions is a simple way to understand the struggles and wars of the sects within faiths. The real question is, can they be contained? Force multiplication is legal, but to what degree can fear be used as a tool of force multiplication, while staying within the boundaries marked by the laws of war. In today's wars within the heavens, Geneva Conventions may be losing steam, because their jurisdiction is being limited with every passing year. The future is not what most of us expected growing up. The paper is an attempt to interpret and simplify certain complex issues and also try to find logical answers for questions that may seem to be a bit illogical.

SOCIAL SCIENCE

Incorporating Academic Solutions to Social Problems

Zendina Mostert

Salt Lake Community College

Changes in the publishing world have hit a critical tipping point. With the transformation of our society to a digitally infused age, and with the prevalence of internet usage, students' reading and study habits are shifting; incorporating information differently than ever before. This

paper will add to the growing body of literature that explores students' scholarly experience with a "Service Learning" Social Problems course in Sociology. The purpose of this paper is to explore students' involvement in interacting with a traditional textbook and the students' ability to incorporate information into a real-world setting. At Salt Lake Community College, we are part of the discussion that allows students to be truly transformed by their academic experiences.

SOCIAL SCIENCE

$\delta 18\text{O}$ Variability in Water Sources on the Colorado Plateau: Preliminaries to Stable Isotope Models of Prehistoric Irrigation

R.E. Burrillo, Michael Lewis, & Joan Brenner Coltrain

University of Utah

Funding was obtained for a pilot study to investigate stable oxygen isotope values ($\delta 18\text{O}$) in water from a variety of sources on Cedar Mesa, in southeast Utah, to examine the feasibility of using $\delta 18\text{O}$ values in plant macrofossils to reconstruct prehistoric irrigation strategies. Results demonstrate enough patterned variability across water sources to support reconstructive modeling.

SOCIAL SCIENCE

MD vs. DO: Stigmatic Language Surrounding the Practice of Osteopathic Medicine Among the Premedical Community

Whitney L. Johnson

Southern Utah University

A research study was done to answer questions about communication used surrounding the osteopathic medical profession. In the present day, there is a much uncertainty surrounding our public and their healthcare. To find out how much the public and medical community know, the Diffusion of Innovation Theory was used to help create research questions and methods related to different aspects of

communication surrounding osteopathic medicine. The study used a data analysis of survey results taken from a group of undergraduate students interested in healthcare. The first survey done consisted of 87 students, while the second group of students consisted of 67. Once the survey was analyzed, it was concluded that the results were not significant—that students had not learned enough information to determine a difference. It was decided that further research is needed in this field to ascertain more thorough and advanced results to answer questions about the future of language and messages in osteopathic medicine for change to take place. More education is needed for people and public to make informed decisions.

