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Editor's Column

Dear readers,

You are offered the eighth issue of the **Journal of Research in Innovative Teaching (JRIT)**, published annually by National University since 2008. The journal plays an important role in demonstrating the steady progress that the institution has made in establishing a research culture. In accordance with National University's mission to make lifelong learning opportunities accessible, challenging, and relevant to a diverse population, the annual publication of a research journal is an important benchmark in the university's maturation process. Teaching, research, and scholarship are interrelated. Research, particularly scholarship in the areas of teaching and learning, enriches teaching and is capable of significantly improving the quality of education. Therefore, a strong commitment to research forms an essential part of the university's overall culture.

The JRIT is an annual, multidisciplinary, peer-reviewed publication of original research focused on effective new instructional approaches, methods, and tools. It is intended to produce momentum in our quest for excellence; increase efficiency of research, scholarship and learning; and to ensure better learning outcomes for our students. The journal is a forum for sharing faculty accomplishments in this area both within the National University community and with the outside world of academia, which will ultimately benefit both the university's academic community and our students. The editorial board is composed of top academics and administrators from National University, as well as national and internationally acclaimed scholars. The review board includes both internal and external reviewers.

This issue features 12 articles accepted after a rigorous double review process. Among the authors you will find National University faculty members, outside scholars working with National University faculty members, U.S. academics from outside the university, and international researchers.

Each article in this issue has been assigned to one of the following sections:

- General Issues
- Mathematics Instruction
- Education and Business Training
- Technology-Based Teaching and Learning
- Language Education
- Assessment and Evaluation

The first article in the **General Issues** section by R. D. Nordgren, *The Age of Accountability in Education: Modernist Approaches to School Reform* examines major school reforms in the U.S., the most recent of which ushered in the "Age of Accountability" that controls schooling today. These reforms are Modernist in their approach, perhaps inadequately preparing graduates for success in the 21st century economy, especially if preparedness is to be measured by standardized test results. A Post Modern approach, which the author proffers, will better prepare citizens for the global economy, as well as active participation in a democratic society.

In her article *Humor and Self-Efficacy Traits that Support the Emotional Well Being of Educators*, Teri Evans-Palmer indicates that educational research has overlooked the association

between teachers' sense of humor and instructional self-efficacy. Her article examines the humor teachers employ to deliver effective instruction, and the stress-moderating effects of humor on their emotional health. Her findings support a positive relationship between social humor and instructional self-efficacy when controlling for age, gender, experience, and perceived stress. Implications of this analysis call for support of teachers' affective health in school environments.

In the **Mathematics Instruction** section, Michael G. Voskoglou presents the article *Mathematical Modelling as a Teaching Method of Mathematics*. The author analyzes mathematical modeling as a tool for teaching Mathematics, through which students can understand the usefulness of mathematics in practice by connecting it with real-world applications. Further, methods for assessing students' mathematical model building skills are presented (calculation of the means, GPA index, COG defuzzification technique) and compared to each other through a classroom experiment performed recently with students of the School of Technological Applications of the Graduate Technological Educational Institute (T. E. I.) of Western Greece.

Olena V. Semenikhina and Marina G. Drushlyak in *The Necessity to Reform Mathematics Education in Ukraine* argue for the need to reform mathematical education in Ukraine. The authors trace the impact of information technologies on the learning process, development, and updating of mathematics software and identify reasons for reform. Possible paths for transforming the system of math education are demonstrated, taking into account the harmonious combination of mathematical knowledge and specialized mathematics software; the level of development of mathematics software and its study; updating the curricula by introducing a "Computer Mathematics" course, use of research approaches instead of computational ones; and formation of cross-disciplinary and extracurricular links in Mathematics.

The section **Education and Business Training** presents the article *The Nexus between Education and Training: Implications for the Adult Learner* by Thomas M. Green, Chandrika M. Kelso, and Don Zillioux. The authors write that over the past four decades, the number and percent of adults attending colleges and universities has significantly increased. During this same period, corporate and business training for adult employees has grown to as much as $200 billion a year. Extensive research in both higher education and corporate training clearly demonstrates that understanding how adults learn has reduced barriers to their success. This paper explores the implications of applying educational best practices for adult learners to work-related training, and vice-versa.

The **Technology-Based Teaching and Learning** section features four articles.

In their article *Technology Integration in the Resource Specialist Program Environment: Research-Based Strategies for Technology Integration in Complex Learning Environments* Jennifer Courduff and Amanda Szapkiw explore the process through which special education teachers transferred technology knowledge to instructional integration. Based on situated learning theory, they utilize design-based research methods to explore how the two-part strategy of participation in a community of practice and the use of matrices affected perceived value, frequency, and progress toward instructional synthesis. Their findings indicate qualitative changes in teaching practices due to raised awareness of technology tools, collaboration within a community of practice, and increased student engagement. Implications include improved technology integration strategies for pre-service teacher education coursework and professional development.

Bryan K. Allen, Gordon W. Romney, Pradip Peter Dey and Miles D. Romney offer the article *Collaborative Academic-Government Agile Development of a Cloud Prototype Fire*

Retardant Drop Log Application for Wildfire Management. They developed a computerized system for combatting wildfires using Agile concepts in both pedagogy and systems development. State-of-the-art cloud infrastructures were used to implement a free, proof-of-concept digital Drop-Log on Azure Cloud using a MySQL database.

The article *Communication, Collaboration and Relationships in the Online College Class: Instructors' Perceptions* by Peter Serdyukov & Cynthia Sistek-Chandler investigates the role of socialization and interactivity in online university classes and, through instructors' perceptions, attempts to understand current trends in online education while outlining future developments in this area.

Nelson Altamirano in *Economics, Engagement and Deeper Learning: Game Design Methodology Approach* states that teaching microeconomics with games usually requires the instructor to create games and play them in the classroom. This approach, as the author claims, is too costly for the instructor and does not ensure deeper learning. A better alternative is the game design methodology approach; it reduces instructor's costs and increases the chance of students' gaining deeper learning through the use of Excel-based teaching tools and group assignments that ask students to create their own games.

In the **Language Education** session Mojgan Rashtchi and Vida Karami present the article *Adopting a New Identity: A Technique to Improve Writing Skill.* This study investigates whether adopting a new identity could impact the writing ability of Iranian EFL learners. The results of the independent samples *t*-test and repeated measures ANOVA showed that the experimental group outperformed the control group.

The final session, **Assessment and Evaluation** features two articles.

Nataliya Serdyukova writes that indirect assessment allows educators to obtain valuable data that can be used for the enhancement of teaching and learning in her article *What Does Indirect Assessment Tell Us?* Her paper reports a pilot study of students' perceptions about two courses in General Physics taught in different formats using a survey as an indirect assessment instrument. The study aims to identify key issues in the course content, structure, and delivery; to appraise and compare these courses; and to develop recommendations for improvement.

In his article *Improving the Uniformity and Consistency of the End-of-Course Evaluation Response Mappings to Numerical Quantities by the use of Fine-Grained Answers and Guidelines* S. R. Subramanya continues discussion of the end-of-course evaluations started in the previous issue. He states that, despite being administered for over fifty years and studied extensively, no single end-of-course evaluations scheme has emerged that is uniform and consistent. He proposes a scheme that provides a set of fine-grained answers to each question and a simple but well-defined set of guidelines for answering the questions. These are expected to improve the uniformity and consistency of the student responses.

Note to the Author offers guidelines for authors submitting their papers to the *Journal of Research in Innovative Teaching*.

We invite scholars to submit their research for the ninth issue, to be published in 2016.

Peter Serdyukov
March 1, 2015

General Issues

The Age of Accountability in Education: Modernist Approaches to School Reform

R. D. Nordgren

Abstract
The author examines major school reforms in the U.S., the most recent of which ushered in the "Age of Accountability" that controls schooling today. These reforms are Modernist in their approach, perhaps inadequately preparing graduates for success in the 21st century economy, if preparedness is to be measured by results on standardized tests. A Post Modern approach, which the author proffers, will better prepare citizens for the global economy as well as active participation in a democratic society.

Key Words
School reform, postmodernism, international education, curriculum, instruction

Introduction

Since the publication of *A Nation at Risk* in 1983 (U.S. Department of Education), the U.S. education system has undergone reforms that run contrary to their implied, if not stated, overarching purpose of preparing the nation's citizens for the global economy (Tienken & Orlich, 2013). The reforms used over the past 30 years are based on "Modern," Industrial-age strategies that are, as this article intends to illustrate, the wrong strategies to increase student achievement and foster productive workers in a Post Modern world (Slattery, 2006). Although it would be shortsighted to believe that education is merely to help students become financially successful, it is this acceptance by both major parties in the U.S. that narrows this article's focus to that of "schooling for the workforce" (Lubienski & Lubienski, 2013; Tienken & Orlich, 2013). The reforms ushered in the "Age of Accountability" in U.S. schools, an era that finds policymakers and funding agencies using "carrots and sticks" to increase student achievement. These tactics may be damaging educators' ability to help their students find economic success in their futures, if results in standardized tests are used to measure such ability. This apparent misguidedness may be due to an outdated view of schooling and about teaching and learning; a view held by policymakers and/or influential for-profit and non-profit entities that increasingly control the destiny of the nation's 100,000 public schools (Lubienski & Lubienski, 2013; Ravitch, 2013; Tienken & Orlich, 2013). This article provides a brief account of schools precursing the Age of Accountability, identifies some of the fallacies of the reforms emanating from it, and provides a glimpse of a "Fourth Way" of conducting schooling that may correct this misdirection.

The Modern–Post Modern Divide

Appendix A attempts to establish the main differences between Modernism and Post Modernism in schooling. The former utilizes teacher-centered instructional strategies, standardized curricula published by sources outside the school, and assessment systems that provide easily quantifiable data to be used to satisfy administrators who may use "data driven" instead of "data informed" management (Hargreaves & Fullan, 2012). By contrast, a Post-Modernist approach embraces student-centered instruction/facilitation of learning, teacher-developed curriculum based on

research and the teacher's knowledge of the students' needs, and variety of assessments, including "authentic" assessment (Slattery, 2006).

Dueling Philosophies

U.S. school reforms emanate from the dueling philosophies of the Founding Fathers. The history of U.S. education is rife with debate about the purpose of schooling, dating back to the Jeffersonian Democratic-Republican battles with the Hamilton and Monroe–led Federalists in the latter part of the 18th century to present day. Jefferson desired schooling for all, to find and cultivate talent from the masses so as to broaden the population from which to select leaders (Tienken & Orlich, 2013). Federalists favored a dual system of education: one for the elite who would be prepared to lead society, and another to provide rudimentary basic skills to those of the lower classes, preparing them to be followers (Tienken & Orlich, 2013). The purpose of compulsory schooling, while still debated, currently consists of support for the economy rather than that of personal fulfillment or social justice (Lubienski & Lubienski, 2013; Tienken & Orlich, 2013), which is why, as noted earlier, this article narrows its focus to education for economic purposes.

Sputnik, the First Call to Arms

U.S. school reforms frequently have militaristic overtones, most famously demonstrated by then-Secretary of Education Terrell Bell's statement in 1983's *A Nation at Risk*: "If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war" (U.S. Department of Education, 1983). In 1957, the Soviet Union sent a satellite into space, causing shock waves across the world but particularly in the U.S., the Soviet's arch-enemy in the Cold War. President Eisenhower was at first unshaken, being well aware that the Americans had a rocket capable of sending a craft into orbit; however, he had opted not to send this craft into space as he feared a "space race" would lead to World War III (Tienken & Orlich, 2013). Under pressure from the ensuing media frenzy, Eisenhower used the event to increase funding for scientific research for prominent U.S. universities *and* to call for more mathematics and science in the K–12 schools (Berliner & Glass, 2014; Tienken & Orlich, 2013). Nearly 60 years later, *Sputnik* is still a reference point upon which all other major U.S. education initiatives are compared. For instance, President Obama and his education secretary, Arne Duncan, have evoked the specter of *Sputnik* to create a sense of urgency in order to launch "Race to the Top" (R2T) (Ravitch, 2013; Tienken & Orlich, 2013).

Examining the overall U.S. schooling situation, circa 1957, made Tienken and Orlich (2013) question the need for an increase in mathematics and science knowledge. This same school system had produced those who developed the atomic bomb (with the assistance of political refugees from Nazi Germany), and who would ultimately put a man on the moon. If the National Defense Education Act, which Eisenhower drafted shortly after *Sputnik*, did actually increase the both the number of mathematicians and scientists, as was its intent (Ravitch 2010; Tienken & Orlich, 2013), then these, say, high school students in the late '50s and early '60s would still have been in graduate school by the time the designs for Apollo 11 were completed. The Act clearly had no impact on NASA's success in the 1960s (Tienken & Orlich, 2013). This was, to

borrow from Berliner and Biddle (1995), a "manufactured crisis." It was a case of an administration being embarrassed by the success of its sworn enemy and reacting in the easiest way possible: blame an element of society that could not or would not fight back (Berliner & Glass, 2014; Ravitch 2010; Tienken & Orlich, 2013). Little or no fight came from schools and universities, as this Act could mean a windfall of federal funding (Berliner & Glass, 2014; Lubienski & Lubienski, 2013). A unified resistance from K–12 schools was lacking after *A Nation at Risk* (addressed below) for the same reason: Acceptance possibly meant more funding (Lubienski & Lubienski, 2013).

A Nation at Risk: The Second Launching of *Sputnik*

By the late 1970s, effects of globalization had negatively impacted the U.S. economy, which found that the Japanese auto industry had cut deeply into U.S. car manufacturers' market share (Reich, 2002; Tienken & Orlich, 2013). Worried politicians went back to the Eisenhower playbook and blamed schools (Ravitch, 2010). A *Nation at Risk* was commissioned by President Reagan to examine the U.S. compulsory education system, but with the unwritten hopes of also privatizing it, and replacing the Department of Education, which had been put into place by his predecessor, President Carter (Lubienski & Lubienski, 2013). Rather than reducing the size and power of the federal government, as was a major theme of the Reagan Administration (Tienken & Orlich, 2013), the report actually led to increased federal involvement in education, as will be shown. Secretary Bell led a commission that was to investigate the following:

- Assess the quality of teaching and learning in the nation's public and private schools, colleges, and universities.
- Compare U.S. schools and colleges with those of other advanced nations.
- Study the relationship between college admissions requirements and student achievement in high school.
- Identify educational programs that result in notable student success in college.
- Assess the degree to which major social and educational changes in the last quarter century have affected student achievement.
- Define problems that must be faced and overcome if the nation is to successfully pursue the course of excellence in education (U.S. Department of Education, 1983).

The commission's recommendations were as follows:

- *Increased content:* "Four years of English; (b) three years of mathematics; (c) three years of science; (d) three years of social studies; and (e) one-half year of computer science for high school students." The commission also recommended that students work toward proficiency in a foreign language starting in the elementary grades.
- *Increased standards and expectations:* The commission cautioned against grade inflation and recommended that four-year colleges raise admissions standards and standardized tests of achievement at "major transition points from one level of schooling to another and particularly from high school to college or work."
- *Increased time:* The commission recommended that "school districts and state legislatures should strongly consider 7-hour school days, as well as a 200- to 220-day school year."
- *Increased instructional compensation:* The commission recommended that salaries for teachers be "professionally competitive, market-sensitive, and performance-based," and

that teachers demonstrate "competence in an academic discipline."

- *Increased levels of leadership and fiscal support:* The commission noted that the federal government plays an essential role in helping "meet the needs of key groups of students such as the gifted and talented, the socioeconomically disadvantaged, minority and language minority students, and the handicapped." The commission also noted that the federal government also must help ensure compliance with "constitutional and civil rights," and "provide student financial assistance and research and graduate training" (U.S. Department of Education, 1983, Recommendation A).

All of these recommendations required a more formal oversight by the federal government to ensure their compliance, thus setting the state for increased federal involvement (Tienken & Orlich, 2013). These recommendations strongly reflect a Modern ideology in their emphasis on concrete standards, time, testing of teachers, and insistence on data (Slattery, 2006); and, as was found later, a push by supporters of the commission to institute merit pay for teachers to address the third bullet in the preceding list (Ravitch, 2010).

President George H. W. Bush campaigned as the "education president" and wanted to pick up on the Bell Commission's recommendations. He formed yet another commission made up of the nation's governors and headed by Arkansas' Bill Clinton. Bush convened an "education summit" in 1989 in Charlottesville, Virginia, that had 49 of the 50 state governors in attendance, several business leaders, and some of Bush's cabinet members; however, it should be noted that no educators were in attendance or were invited (Vinovskis, 1989). It was evident that this new commission would be wishing to use business strategies to improve the schools, a Modern approach according to this article's definition (see Appendix A).

The Summit's participants agreed that the nation needed a set of education goals and submitted six possibilities (Vinovskis, 1989), which were adopted (plus two more) the following year by the Bush Administration and eventually became Bill Clinton's *Goals 2000: Educate America Act* in 1994 (Paris, 1994). The Summit's report stated that, by the year 2000,

1. All children will start school ready to learn.
2. The high school graduation rate will increase to at least 90%.
3. All students will become competent in challenging subject matter.
4. Teachers will have the knowledge and skills that they need.
5. U.S. students will be first in the world in mathematics and science achievement.
6. Every adult American will be literate.
7. Schools will be safe, disciplined, and free of guns, drugs, and alcohol.
8. Schools will promote parental involvement and participation. (U.S. Department of Education, n.d.)

It is said that the devil is in the details, and the details were indeed lacking. How were these to be achieved? Was the onus on the federal government, specifically the Department of Education? Or was the responsibility to fall on the states or on the nearly 15,000 school districts? Bill Clinton would attempt to answer these questions by making these recommendations federal initiatives as part of his "Third Way" approach to governance.

Clinton's "Third Way"

The decade of the 1990s found the Democrats, who had historically supported public schools, using the same accountability measures as were advocated by Republicans, thereby setting the stage for a Republican President to have his signature education policy drafted: the No Child Left Behind Act (Elementary and Secondary Education Act of 2002, or "NCLB"). This was enacted despite a growing dissent among the populace regarding the use of standardized testing and an almost unanimous opposition among educators (Berliner & Glass, 2014; Lubienski & Lubienski, 2013; Ravitch, 2013).

The philosophy behind NCLB, such as use of marketplace strategies to force schools to improve, was also supported by a Democratic President (Obama), who rolled out his own signature education policy wrapped up in the *Race to the Top* initiative announced in 2010 (Berliner & Glass, 2014; Ravitch, 2013; Tienken & Orlich, 2013).

In 1994 Clinton used the eight goals from the Charlottesville Summit to introduce the following:

- The National Education Standards and Improvement Council to examine and certify national and state content, student performance, opportunity-to-learn standards, and assessment systems voluntarily submitted by states.
- The National Skill Standards Board to facilitate development of rigorous occupational standards. The Board was to identify broad occupational clusters and create a system of standards, assessment, and certification for each cluster.
- The skills certificate would give students the portable, industry-recognized credentials described in the School-to-Work Opportunities Act of 1994 that indicated mastery of skills in specific occupational areas (North Central Regional Educational Laboratory, n.d., b).

These initiatives reflected a Modern philosophy as they focused almost primarily on readying K-12 students for the world of work; that is, practical over aesthetic (see Appendix A). A Democrat had taken the conservative education policies adopted by Reagan and Bush and turned them into his own (Hargreaves & Shirley, 2012). Clinton, along with British Prime Minister Tony Blair, was the standard-bearer of "The Third Way," which was meant to be an approach to government that was neither conservative nor progressive. However, Clinton's greatest accomplishments were taken from the conservative's playbook:

1. The North American Free Trade Act, which opened the borders of U.S. and Mexico and U.S. and Canada to easier trade, and
2. An "end to welfare as we know it" (Vobejda, 1996).

When it came to education, his policies also came directly from the conservatives' agenda creating a unified philosophy of schooling, one that "reached across the aisles of Congress" (Lubienski & Lubienski, 2013; Ravitch, 2013; Tienken & Orlich, 2013).

NCLB and G.W. Bush

George W. Bush who, like his father, campaigned as the "Education President," declaring education to be a "new civil right" (Rove, 2010). As Texas governor, G. W. Bush had overseen the institution of a statewide school grading system that featured a lock-step Modernist testing

regime; he quickly looked to nationalize such a system using NCLB (Tienken & Orlich, 2013). Working with Democratic Senator Ted Kennedy, the Bush Administration pushed through the NCLB, featuring the following provisions:

1. Public schools receiving federal fund had to use annual standardized testing for all students.
2. Schools receiving Title I funds had to make gains in test scores each year (Adequate Yearly Progress or "AYP") (North Central Regional Educational Laboratory, n.d., a).

In regards to Title I funds emanating from the Elementary and Secondary Act of 1965, one of Lyndon Johnson's key acts in his War on Poverty, schools that did not make AYP would have sanctions taken against them, eventually leading to the removal of teachers, administrators, and the closing of the school. Furthermore, students and their parents would be given a choice to attend another school that was not deemed to be failing (Ravitch, 2010; Tienken & Orlich, 2013). Although states were able to develop their own AYP objectives, they were to follow a strict set of federal guidelines, essentially ensuring a national system of accountability (Lubienski & Lubienski, 2013; Tienken & Orlich, 2013).

NCLB also impacted schools in other ways, such as its insistence on "highly qualified" teachers; this meant, in short, that no student would have a teacher who did not have a state-issued license, certificate, or credential (Berliner & Glass, 2014). Finally, perhaps the most controversial element of the act was the goal that all children in the U.S. would be at grade level by 2014 (Ravitch, 2010, 2013).

The intentions of NCLB were good, according to many of its critics (e.g., Berliner & Glass, 2014; Ravitch, 2013; Tienken & Orlich, 2013), in that it was to identify those populations that do not generally do well in school and refocus reform efforts toward those students. The efforts heavily relied on external motivators; that is, rewards and punishments (see Pink, 2009), which remain favored by Modernists (Slattery, 2006). Schools would be forced to improve test scores or they would eventually have their teachers and principals removed and the school possibly closed down (Ravitch, 2010). This fear of losing one's job was to motivate teachers and principals to improve their practice. School choice was another "stick" used to force schools to improve test scores. Parents whose children attended "failing" schools could send them elsewhere to a "better" school, resulting in undue financial constraints on school districts (Lubienski & Lubienski, 2013). Districts were to administratively support the schools (e.g., payroll, insurance), despite not having received funds for the students (Ravitch 2010; Tienken & Orlich, 2013).

The results of NCLB have been mixed, at best. As noted, the goal of having all children reach grade level by 2014 did not materialize. The Modern approach to focus on easily reported measures did not improve test scores by which schools are held accountable; this is discussed later in the present article (Lubienski & Lubienski, 2013; Ravitch, 2013; Tienken & Orlich, 2013). Below is a brief examination of some of the other goals that the Act hoped to establish.

1. *Increased accountability*. Little doubt exists that NCLB increased accountability in that federal funds in the form of Title I grants were used as enticements (and weapons) to increase test scores across the board. Especially notable was the focus on sub-populations of students; that is, small percentages of minorities in schools would have to show increases in test scores even if the number of students in categories was statistically insignificant.
2. *More choices for parents and students.* Little doubt exists that the Act increased the use of

school choice. The percentage of those who chose their public school rather than automatically accepting the one they were assigned to, rose from 11% to 16% from 1993 to 2007 (Institute of Educational Sciences, n.d., a). However, the real impact may be on the media attention brought to schools whose test scores were low, causing parents to believe these schools had subpar teachers and curricula (Lubienski & Lubienski, 2013; Ravitch, 2013).

3. *Greater flexibility for states, school districts, and schools.* With a strong mandate to use standardized testing as the measure for success, one could argue that flexibility was actually reduced. States had been developing their own sets of standards, each state a little different from the other, yet mostly the same, due, in part, to the pressures created by textbook companies who wanted to standardize across states, allowing them to sell the same book in every market (Ravitch, 2010; Tienken & Orlich, 2013). The intent of the Act was to force schools and districts to become more creative in how they delivered schooling, but a rigid reliance on standardized testing may have actually stifled this creativity (Ravitch, 2013; Robinson, 2011; Wolk, 2011; Zhao, 2009, 2012).
4. *Putting reading first.* This turned out to be a highly controversial goal. Although most would want students to be better readers, the intent of this goal was to increase the use of phonics in reading instruction (Reyner, 2008). For decades, a debate known as the "Reading Wars" had existed among reading scholars, whereby one camp believed that the traditional/Modernist approach, phonics, was preferable over the "whole language" instructional methods (Ravitch, 2010). The G. W. Bush administration provided millions of new dollars in the way of grants. Poor districts were enticed by U.S. Department of Education grants to institute phonics in their schools through a program called "Reading First." Critics saw this as federal intrusion on teachers' practice, as teachers who believed that whole language, or a combination of whole language and phonics, was the best approach to teaching learning, would be marginalized and forced to use phonics (Reyner, 2008).

The debate over NCLB continued on into the Obama Administration, which created its own education policy that, although significantly different in many respects to the Bush policies, still relied on federal intervention for change and used external rewards and punishment to promote this change, thereby making it a Modernist reform movement.

"Race to the Top"

The author was attending a national school superintendent conference in late 2008 and witnessed a panel discussion facilitated by retired CBS news anchor Dan Rather. The panel consisted of a few large city superintendents, including then–Chicago schools Chief Executive Officer Arne Duncan, as well as an education advisor from both the Obama and McCain presidential campaigns. The education policies described by all were nearly identical; and it was clear that accountability measures, such as high-stakes testing, were to continue no matter who was elected President. Duncan was already famous for using accountability to make changes in Chicago, although test scores were stagnant (Lubienski & Lubienski, 2013; Ravitch, 2013). As we now know, Duncan was chosen to be Secretary of Education chiefly for his work in Chicago and his personal ties to President Obama (Ravitch, 2013). Duncan set out to establish the "Race to the Top" (R2T) initiative that awarded states who collaborated on a national set of standards. Thus,

an education in Oregon might be commensurate to one in South Carolina; employers could be assured that a high school graduate from anywhere would have a certain skill set.

The "Common Core"

Emanating from R2T was a new set of standards known as "Common Core." These standards quickly became controversial. Politics played a significant role in this controversy: Republican-controlled states opposed the standards and Democratic-controlled states embraced them (Ravitch, 2013; Tienken & Orlich, 2013). The 48 states initially adopting Common Core were encouraged to change how learning was measured by developing alternative forms of assessment (Lubienski & Lubienski, 2013). But the Common Core standards became politicized in that they were seen by conservatives and conservative politicians in "red states" as a way for President Obama to impede states' rights, to federalize education policy (Lubienski & Lubienski, 2013; Tienken & Orlich, 2013). Of course, the conservative George W. Bush did just this with the use of NCLB, but this was more than just an attack on education policy. The Common Core is deemed by some to be an Obama-administration scheme to curtail individual rights such as freedom of choice (Hess & McShane, 2013). As of 2014, five red states—Alabama, Indiana, Kansas, Louisiana, and Nebraska—had dropped the Common Core or had delayed its implementation. Moreover, Texas, Virginia, and Alaska declined to participate at all. Some blue states (Massachusetts and New York) and politically divided "purple" states (Michigan and Ohio) have delayed implementation (Association for Supervision and Curriculum Development, 2014). But beyond the political squabbling, there may have been a clash of ideologies: the Common Core requires a different type of learning to take place in schools, learning that could not be easily measured by a standardized test. To a Modernist, learning can be simplified to be merely a transfer of knowledge (Slattery, 2006); whereas the Common Core ostensibly requires a deeper understanding of content and the ability to apply it in a useful way (Lubienski & Lubienski, 2013). The ways in which Common Core are implemented, however, cause the reform to fall into the Modern category as is detailed in Appendix A and as follows.

A Modernist Approach

The way the Common Core standards are written implies that they are designed to increase the level of cognitive learning as measured by Bloom's Taxonomy of Cognition (Bloom, 1956). The use of the verbs such as "interpret" and "create" in these standards coincide with the upper level of Bloom's Taxonomy and are not easily assessed by standardized testing, if they can be assessed at all (Ravitch, 2013: Tienken & Orlich, 2013).

Ravitch (2010, 2013) and Berliner and Glass (2014) are some of the noted scholars who question the insistence on psychometrics to make policy decisions (see also Tienken & Orlich, 2013). The mantra "data-based decision making" has been driving educational leadership literature for some time, but it has rarely been questioned (Henig, 2012). Of course, data provide us with information on which we can base our decisions, but which data do we use? For the past few decades, these data have been standardized tests that may or may not have been used correctly. For instance, some psychometricians state that standardized tests should not be used to make decisions about matters for which the tests were not designed; decisions on such areas as merit pay for teachers and principals, student retention in grade, and the closing of schools

(Henig, 2012; Lubienski & Lubienski, 2013; Tienken & Orlich, 2013). Yet, the Modern philosophy of measurement prevails in current school reform, creating an educational policy hegemony and, subsequently, classroom and schooling practices (Ravitch 2010; 2013; Tienken & Orlich, 2013; Wolk, 2011).

Common Core attempts to allow students to learn abstract concepts over facts, making some believe that this is actually a "dumbing down" of the curriculum (Cohn, 2014). To make sense of this belief, one need only examine the Modernist approach to teaching and learning, which is quite linear: The instructor and/or textbooks provide information which the students are to retain and translate onto a test. Modernists either favor the learning of facts over concepts or at least believe that facts, acting as the building blocks of conceptual learning, must be learned in order for concepts to be gained (Slattery, 2006). But the way in which the Common Core was "sold" to states through monetary enticements distributed through R2T grant competitions, and its reliance on standardized testing, despite efforts to find alternative assessments, keep it in the category of a Modernist school reform.

The Modern–Post Modern Divide in School Reform

Appendix A creates a format to better understand the differences between Modernism and Post Modernism as they pertain to education, particularly school reform movements. Table 1 outlines various reforms that that have been attempted, proposed, or imposed during the past two centuries. Not until Hargreaves and Shirley's (2012) "Fourth Way," which used Canada's system as an exemplar, and Sahlberg's (2011) "Finnish Way" have there been true enactments of Post Modernism in school reform. They have made progressive theory a reality (Ravitch, 2013; Sahlberg, 2011).

The First Way is a category used by Hargreaves and Shirley (2012) to denote the initial reform movement, which began during the midst of the Industrial Age and at the beginning of the Scientific Management movement that saw industry using various modes of efficiency to cut costs and "systematically routinize" functions (Reich, 2002). Schools, influenced by Frederick Taylor's work, began implementing changes that were to provide more predictability, differentiate roles, and keep costs low (Tienken & Orlich, 2013). Despite a period of experimentation with Progressivism, this system lasted well into the 20th century until the publication of *A Nation at Risk* (Lubienski & Lubienski, 2013). Although schools and school systems still functioned in highly bureaucratic structures, they are now deeply impacted by accountability measures from outside agencies (Ravitch, 2010).

The Second Way, according to Hargreaves and Shirley, represents the ushering in of the Age of Accountability, which, in some respects more deeply entrenches the schools into Scientific Management (or "Taylorism") and thus Modernism. They became much more mechanistic in nature with increased standardization of the curricula and instructional practices (Tienken & Orlich, 2013). The pinnacle of the epoch is NCLB, which highly mechanized teachers' and administrators' practice (Ravich, 2010, 2013; Tienken & Orlich, 2013; Wagner, 2010; Wolk, 2011).

Table 1. *Education Reforms in the Age of Accountability*

		The First Way[a]	The Second Way	The Third Way	The Fourth Way	The Finnish Way[b]
Pillars of Purpose and Partnership	Reform category	Modern	Modern, GERM[c]	Modern, GERM	Post-Modern	Post-Modern
	Timeframe	Late 1800s–1983	1983–2009	2009–present	N/A	1990–present
	Policies, laws, and resources	Traditional, prior to Age of Accountability	*A Nation at Risk* to "No Child Left Behind"	"Race to the Top" and "Common Core"	Hargreaves & Shirley	Sahlberg
	Purpose	Innovative; inconsistent	Markets and standardization	Performance targets: raise the bar, narrow the gap	Inspiring, inclusive, innovative mission	Inspiring, inclusive, innovative mission
	Community	Little or no engagement	Parent choice	Parent choice and community service delivery	Public engagement and community development	Public engagement and community development
	Investment	State investment	Austerity	Renewal	Moral economy	Moral economy
	Corporate Influence	Minimal	Extensive—charters and academies, technology, testing products	Pragmatic partnerships with government	Ethical partnership with civil society	Ethical partnership with civil society
	Students	Happenstance involvement	Recipients of change	Targets of service delivery	Engagement and voice	Engagement and voice
	Learning	Eclectic and uneven	Direct instruction to standards and test requirements	Customized learning pathways	Truly personalized; mindful teaching and learning	Truly personalized; mindful teaching and learning
Principles of Professionalism	Teachers	Variable training quality	Flexible, alternate recruitment	High qualification, varying retention	High qualification, high retention	High qualification, high retention
	Associations	Autonomous	De-professionalized	Re-professionalized	Change-makers	Change-makers
	Learning Communities	Discretionary	Contrived	Data-driven	Evidence-informed	Evidence-informed

Table 1—*continued*

		The First Way[a]	The Second Way	The Third Way	The Fourth Way	The Finnish Way[b]
Catalysts of Coherence	Leadership	Individualistic; variable	Line managed	Pipelines for delivering individuals	Systemic and sustainable	Systemic and sustainable
	Networks	Voluntary	Competitive	Dispersed	Community focused	Community focused
	Responsibility	Local and little accountability	High-stakes targets; testing by census	Escalating targets, self-monitoring, and testing by census	Responsibility first, testing by sample, ambitious and shared targets	Responsibility first, testing by sample, ambitious and shared targets
	Differentiation and Diversity	Underdeveloped	Mandated and standardized	Narrowed achievement gaps and data-driven interventions	Demanding and responsive teaching	Demanding and responsive teaching

[a]The First, Second, Third, and Fourth Way terms and descriptions beneath it are from A. Hargreaves & D. Shirley, *The Fourth Way: The Inspiring Future for Educational Change*. Thousand Oaks, CA: Corwin, 2012.

[b]The Finnish Way term and descriptions beneath it are from P. Sahlberg, *Finnish Lesson: What Can the World Learn from Educational Change in Finland?* New York: Teachers College Press, 2011.

[c]"Global Educational Reform Movement," from P. Sahlberg, *Finnish Lesson: What Can the World Learn from Educational Change in Finland?* New York: Teachers College Press, 2011.

The advent of R2T and Common Core appeared to be a way of using Clinton's Third Way for school reform; that is, providing a bridge between the Modern and the Post Modern. It still requires many aspects of Modernism to be implemented but could nevertheless be a step in the direction toward a more progressive system of schooling when it comes to teaching and learning (Ravitch, 2013).

Hargreaves and Shirley (2012) described how Canada's system, especially Ontario, utilizes a different way of approaching schooling, one that advocates student-centered instructional practices and empowers teachers and school-based administrators. This system is similar to the Finns', where curriculum and assessment measures are generated at the local level, designed by practitioners rather than textbook publishers (Sahlberg, 2011; Ravitch, 2013; Tienken & Orlich, 2013).

A 30-Year Report Card on Accountability in the U.S.

Reforms are ostensibly to improve education results, which one would hope would improve the chances that "products" of the P–12 systems will be successful in the new economy, thereby, improving the nation's economic health. U.S. schools, however, are still entrenched in the Age of Accountability, which utilizes the tenets of Modernism (see Appendix A). Has this approach improved the process of schooling in the U.S? If so, then there is no need to pursue a Fourth

Way or emulate the Finns. The U.S. schooling process is multi-faceted in that myriad measures can be used to examine the economic and social conditions over the past 30 years. However, it seems logical to use the same measures employed by the Accountability Movement to judge teachers, principals, and schools as a way to determine if an improvement has been made in the quality of education in this nation. Therefore, this section examines three of the leading standardized tests that are used by policymakers and the media as indicators of student achievement (Tienken & Orlich, 2013).

The Trends in Mathematics and Science Study (TIMSS)

Although this test had predecessors, the actual TIMSS was first used in 1995 and has been administered every four years since. In 2011, over 60 nations participated (Institute of Educational Sciences, n.d., a). This measure is deemed important to those who see the primary function of schooling to be workforce enhancement. Science, technology, engineering, and mathematics ("STEM") jobs are considered to be a key sector for future job growth, although this is not without criticism (e.g.; Ravitch, 2013, Teinken & Orlich, 2013). The U.S., as widely publicized in the media, does not fare as well as would be expected, given how much it spends on K–12 schooling (Lubienski & Lubienski, 2013). These poor showings prompt many to believe that the nation will fall behind in technology; a fear that, so far, is unfounded (Teinken & Orlich, 2013; Zhao, 2012). Zhao (2009) made a case that TIMSS is a poor indicator of future economic success by noting that those nations that have historically done well on this test have shown weak economic improvement, whereas those with weaker TIMSS results have done quite well. Still, this test, coupled with the belief that the STEM fields are developed nations' best attempt at increasing job numbers, keeps TIMSS in the media spotlight.

Program for International Student Assessment (PISA)

First administered in 2000, it has been taken by as many as 75 nations (Institute of Educational Sciences, n.d., b). The test for 15-year olds measures mathematics, reading, and science and, in 2014, will also measure financial literacy (Institute of Educational Sciences, n.d., b). The results of this test have also brought concern to politicians and citizens alike in many developed countries, including the U.S. In 2011, Finland ranked first in the world for PISA and received much attention, largely to their chagrin. It seemed educators there were not concerned about test scores and saw them as merely one measure of what a student has learned (Sahlberg, 2011). Interestingly, Finns focus on teaching the "whole child" rather than focusing on test-taking, a criticism of U.S. education (Schwartz & Mehta, 2011; Ravitch, 2013). It is interesting to note that since Sweden implemented a Modernist approach to education after the 2006 general elections, their PISA scores and rankings have plummeted. Raising the PISA scores was the stated main objective for changing the schooling system (Adams, 2013).

The National Assessment for Educational Progress (NAEP)

This may be referred to as the gold standard of standardized testing in the U.S. (Tienken & Orlich, 2013). The NAEP website proclaims that it is "the largest nationally representative and continuing assessment of what America's students know and can do in various subject areas" (Institute of Education Sciences, n.d., c). NAEP assessments are conducted periodically in mathematics, reading, science, writing, the arts, civics, economics, geography, U.S. history, and (beginning in 2014) in Technology and Engineering Literacy (Institute of Education

Sciences, n.d., c). The Finns also use representative sampling for their one-and-only standardized test given to 15-year olds (Sahlberg, 2011). As the Finnish test and the NAEP are not taken by all students, and given the fact that no rewards or punishments accompany their results, then these tests cannot be considered "high stakes." By using a random sampling, a true indicator of how a nation's students are performing can be determined, at least in what is tested and how these are tested—and without the need to test all students, saving expense and anguish. Typically, 2,500 students in 100 schools (public and private) in each U.S. state are tested (Institute of Education Sciences, n.d., c).

As the NAEP has been administered on a long-term basis, some of the following listed findings provide evidence that U.S. schools are truly not failing, contrary to the consensus among media and education critics (Ravitch, 2010):

- Compared to the first assessment in 1971 for reading and in 1973 for mathematics, scores were higher in 2012 for 9- and 13-year-olds and not significantly different for 17-year-olds.
- In both reading and mathematics at all three ages, Black students made larger gains from the early 1970s than did White students.
- Hispanic students made larger gains from the 1970s than did White students in reading at all three ages and in mathematics at ages 13 and 17.
- Female students have consistently outscored male students in reading at all three ages, but the gender gap narrowed from 1971 to 2012 at age 9.
- At ages 9 and 13, the scores of male and female students were not significantly different in mathematics, but the gender gap in mathematics for 17-year-olds significantly narrowed by 2012, especially in comparison to what it was in 1973 (Institute of Educational Sciences, n.d., c).

Modernism and School Reform: The Effects on Schooling in the U.S.

The "carrot-and-stick" approach employed by NCLB and R2T was quickly criticized by the education community (Ravitch, 2013; Tienken & Orlich, 2013). Schools were viewed by the general public as mediocre (Phi Delta Kappa International, 2013) and by politicians as failing (Lubienski & Lubienski, 2013; Tienken & Orlich, 2013). Reminiscent of the panic caused by the launching of *Sputnik* in 1957, a call was made to make the "products" (graduates) of schools more competitive with those from around the world, especially in mathematics and science (Lubienski & Lubienski, 2013; Tienken & Orlich, 2013). A key measure of this competition was TIMMS. The prevailing thought is that more engineers and mathematicians are needed in the U.S. so as to stay competitive in the world of advanced technology. However, Zhao (2012) and Ravitch (2013) pointed out that globalization has made any job (or profession, for that matter) that can be "systematically routinized" (see Reich, 2002) a target for being outsourced to a developing nation where the cost of labor is a small fraction of that of a developed nation, e.g., call centers in India, where a person who can speak English can function by simply following a script and/or a flow chart of responses, and who can and will do this for much less than a person in the U.S., as the cost of living is much less in these nations (Reich, 2002). Tienken and Orlich (2013) used myriad data to argue that a shortage of jobs in mathematics and science is a myth, that this is simply a way to depress labor costs in industries such as advanced technology.

1. As Zhao (2009) claimed, it may "simply" be a case that the wrong things are being

measured. What the U.S. offers that the developing nations do not, especially those in East Asia and the subcontinent to which U.S. jobs are outsourced, is a school system that fosters creativity, albeit this is done unwittingly. Zhao believed that the goals of the Asians and the U.S. schools are similar; that is, to create good test takers. But the Asians do a better job of this, according to Zhao. As the U.S. fails at creating good test takers, more creativity is fostered in the U.S. schools, which are not as controlling as those of the Asians. Creativity cannot occur in a highly controlled environment (Pink, 2009; Wagner, 2010). Accountability, in Zhao's (2009) view, stifles creativity in its quest to produce better employees. A highly controlled system may indeed raise test scores, as the Asians have found, but it is counterproductive in creating the type of worker that the 21st century needs. Sahlberg (2011) suggested that de-emphasizing testing could actually increase test scores.

2. According to The Partnership for 21st Century Skills (n.d.) and other school reform scholars, such as Hargreaves & Fullan (2012), Tienken and Orlich (2013), and Wolk, (2011), a more highly complex set of skills and knowledge will need to be acquired and attained for our nation's learners to be able to contribute to the nation's economy and, for that matter, to a public democracy (Goodlad, 2004). These skills include critical thinking, effective communication, adaptability, and other non-cognitive variables (see Sedlacek, 2006). As the world is ever-changing and unpredictable, the jobs of today may not exist tomorrow, so the need exists to create a "lifelong learner" who can not only adapt and learn new skills but be proactive in helping to shape society (Wagner, 2010).

Conclusion

This article examined waves of school reforms and categorized them into Modernism and Post Modernism. The former is viewed as dominant in the U.S. and is a philosophy that may be incompatible with the need to improve student achievement. It is implied above that the goal of a strong economy and workforce cannot be achieved by using Modern systems. Post Modern systems such as those employed by Canada and Finland should be considered if the U.S. is to remain a viable economic force.

3. Despite the current debate about what should be learned and how it is to be assessed, the prevailing ideology is that of Modernism (Slattery, 2006). That is, those who shape the institution of schooling believe it is to be predictable and the measures should be concrete (Tienken & Orlich, 2013). One key reason for adoption by the U.S. of Modernist school reforms is that these reforms depend on quantifiable data that is easy to report to the community and in the media (Tienken & Orlich, 2013). The validity of these data are in question by many, in that they do not measure what really needs to be known for our high school graduates to succeed in the global economy and contribute to a public democracy (Ravitch, 2010; 2013; Tienken & Orlich, 2013; Wolk, 2011; Zhao, 2009, 2012). The content in tests such as TIMSS is indeed important; however, that content is not all that needs to be measured and may not be as important as, perhaps, non-cognitive variables (or "soft skills") that may be a better indicator of success in the global economy and global village (Sedlacek, 2006).

4. It is hoped that examinations such as those found in this article will spur policymakers and the general public to rethink how schooling is conducted in the U.S. The author also hopes to ignite conversations among university education faculty to consider the overall scenario of U.S. schooling.

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Appendix A
Modern/Post-Modern Teacher Education Contrasts

Modern advocates in theory and/or practice	Post-Modern advocates in theory and/or practice
1. Standardizing teaching and learning a. Setting clear, high, and centrally prescribed performance expectations for all schools, teachers, and students to improve the quality and equity of outcomes. b. Standardizing teaching and curriculum in order to have coherence and common criteria for measurement and data.	1. Customizing teaching and learning a. Setting a clear but flexible national framework for school-based curriculum planning. b. Encouraging local and individual solutions to national goals in order to find best ways to create optimal learning and teaching opportunities for all. c. Offering personal learning plans for those who have special educational needs

Appendix A—*Continued*

Modern advocates in theory and/or practice	Post-Modern advocates in theory and/or practice
2. Focus on literacy and numeracy a. Basic knowledge and skills in reading, writing, mathematics, and the natural sciences serve as prime targets of education reform. Normally instruction time of these subjects is increased.	**2. Focus on creative learning** a. Teaching and learning focus on deep, broad learning, giving equal value to all aspects of the growth of an individual's personality, moral character, creativity, knowledge, and skills.
3. Teaching prescribed curriculum a. Reaching higher standards as a criterion for success and good performances. b. Outcomes of teaching are predictable and prescribed in a common way. c. Results are often judged by standardized tests and externally administered tests.	**3. Encouraging risk-taking** a. School-based and teacher-owned curricula facilitate finding novel approaches to teaching and learning, and encourage risk-taking and uncertainty in leadership, teaching, and learning.
4. Borrowing market-oriented reform ideas a. Sources of educational change are management administration models brought to schools from the corporate world through legislation or national programs. b. Such borrowing leads to aligning schools and local education systems to operational logic of private corporations.	**4. Learning from the past and owning innovations** a. Teaching honors traditional pedagogical values, such as teacher's professional role and relationship with students. b. Main sources of school improvement are proven good educational practices from the past.
5. Test-based accountability and control a. School performance and raising student achievement are closely tied to processes of promotion, inspection, and ultimately rewarding schools and teachers. b. Winners normally gain fiscal rewards, whereas struggling schools and individuals are punished. Punishment often includes loose employment terms and merit-based pay for teachers.	**5. Shared responsibility and trust** a. Gradually building a culture of responsibility and trust within the education system that values teacher and principal professionalism in judging what is best for students. b. Targeting resources and support to schools and students who are at risk to fail or to be left behind. c. Sample-based student assessments.

Derived from P. Sahlberg, *Finnish Lesson: What Can the World Learn from Educational Change in Finland?* (New York: Teachers College Press, 2011).

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Humor and Self-Efficacy Traits that Support the Emotional Well-being of Educators

Teri Evans-Palmer

Abstract
Educational research has overlooked the association of teachers' sense of humor and instructional self-efficacy. This article examines the humor teachers employ to deliver effective instruction and the stress-moderating effects of humor on their emotional health. Findings of a prior study by the author support a positive relationship between social humor and instructional self-efficacy when controlling for age, gender, experience, and perceived stress. Findings synthesized with literature reveal five behavior traits that are shared by both constructs: social connectedness, emotional intelligence, resilience, self-monitoring, and divergent thinking. Implications of this analysis call for support of teachers' affective health in school environments.

Key Words:
Teacher self-efficacy, humor, emotional intelligence, resilience, stress, divergent thinking, immediacy

The Problem: Emotional Well-being of Teachers Challenges Self-Efficacy

Humor serves all teachers well when problems arise that stymie their affective wellbeing. At one point in my career, this author taught art in a high school infamous for gang fights, a high dropout rate, and ghastly teacher attrition. To sidestep daily doses of disillusionment, the author relied on quirky approaches that seemed to motivate reluctant students, such as "warming up" "cold" pencils, brought out the "I Can" (a soda can plastered with photos of eyes), occasionally speaking with a British accent, leaping onto desks, sporting a magic wand, and pulling a number of metaphors out of the air to clarify concepts. In doing so, the author felt a sense of control over the tiresome student apathy that permeates high school classes as social smokescreens that encumber instruction. The author felt lighter, happier, and more connected to the students. The author also observed that colleagues who possessed a developed sense of humor enjoyed enhanced rapport with their high-achieving students. Many of these teachers shared personality or behavior traits that perpetuated their success, no matter how difficult their jobs were. This observation, coupled with the author's own experiences linking humor to emotional health, triggered an investigation of humor's association with teacher self-efficacy. What behavior traits of teachers with high humor orientation fostered positive perceptions of their teaching performance? Were these traits somehow interrelated?

Purpose

In a previous study, the present researcher explored the relationship between the multidimensional constructs of humor and self-efficacy with K–12 public school art educators (Evans-Palmer, 2010). A correlational analysis demonstrated a moderate, positive relationship between teachers' social humor and instructional efficacy. More clearly, many of the teacher participants ($n = 354$) who advanced learning with humor were also those who held strong efficacy beliefs and remained resilient to stressors in unresponsive school environments.

When the findings alongside literature for humor and self-efficacy were compared, behavior traits common to both constructs emerged at conceptual intersections. The traits described

behaviors that characterize effective teacher performances and are interrelated along five affective themes within teachers' affective/emotional, social, and cognitive processes. The themes interrelating sense of humor with teaching self-efficacy are social connectedness, resilience, emotional intelligence, self-monitoring, and divergent thinking. This article endeavors to explain how these themes apply to teaching in a theoretical comparison and explains what roles they play in moderating self-efficacy. Finally, it recommends that teacher training program directors and public school administrators consider professional development to shore up teaching resilience with humor. The implications of this proposal could recover the affective health of experienced educators and better prepare pre-service teachers.

The Present Challenge to Efficacy

A teaching colleague recounted to this author a day when she met her students at the door with high expectations for classes. Materials were ready, visual presentations were prepared, and her mind was cued up for performance. Within seconds after the bell, the trickle of students soon swelled to a river, and within 5 minutes she had disarmed an arguing twosome, caught a flying pen, encouraged a sullen sad sack, hushed a cursing senior, and addressed a visiting administrator's concerns. She chuckled to herself because she knew that these small skirmishes were not the thundering cloudburst that often threatened her sunny disposition. My friend resolved to persevere because she sensed that buoyancy was as important to good teaching as breathing was to survival. Each class brought new waves of burgeoning calamities, eroding away her sense of self-efficacy, her capability to join her students with self and subject in order to teach well.

This author's colleagues, along with many educators in public school communities, struggle to stay afloat in a perfect storm of policy changes that have precipitated budget cuts, curriculum mandates, and resource reductions (Chapman, 2007; Johnson, 2007). They are bearing the weight of rising job responsibilities spawned from high stakes testing (Freedman, 2007). An outpouring of new technologies to enhance instruction may be seen, but support for the very ones who are expected to carry out instruction has all but evaporated (Schonfeld, 2001; Yatvin, 2008). Educators rely heavily on personal attributes to sustain emotional health in this sea of critical issues and are expressly weighted with the task of maintaining a learning environment that is conducive to creativity. It has become increasingly problematic to deliver quality instruction to classes of diverse learners who represent a range of social, cognitive and skill abilities. Academic subject content has been narrowed to allow time for requisite test skills; class time can no longer be wholly dedicated to the subject (Bobick & DiCindio, 2012).

Fallout for educators in this vexing educational milieu appears on an affective spectrum ranging from declining self-confidence to severe health problems, burnout, early retirement, and high attrition (Luekens, Lyter, Fox, & Chandler, 2004; Scheib, 2006). To be sure, the realities of teaching in public school environments are fraught with frustration. Compelling evidence asserts that, "teachers' assessment of key resources and supports in their teaching contexts contributes to their efficacy judgments" (Tschannen-Moran & Hoy, 2002, p. 2). Teachers' self-efficacy beliefs and perceptions of their power to control situations moderate both their perseverance and performance in tough times. The more emotionally resilient to challenges teachers remain, the more able they are to direct their efforts to solve problems and not focus on relieving their emotional distress (Schonfeld, 2001).

Humor's Effect on Instructional Self-Efficacy

Social learning theory refers to teaching self-efficacy as the perceptions of a teacher's ability to motivate and promote student learning (Bandura, 1993; Gibson & Dembo, 1984). The personal agency of self-efficacy (judgment of capability) is unlike that of self-esteem (judgment of self-worth) and is just one part of a larger self-system that comprises attitudes, abilities and skills. Self-efficacy seems to play a more essential part than skills in endowing teachers with abilities to succeed in specific pedagogical tasks (Bandura, 2006; Coladarci, 1992). Quite plainly, what teachers *believe* about their ability to perform a task is far more potent than their *ability* to actually perform the task (Pajares, 2002).

Beliefs of self-efficacy have a significant impact on teachers' psychological states, behavior, and motivation, and they moderate the level of stress they can tolerate (Friedman & Kass, 2002; Henson, 2001; Tschannen-Moran, Hoy, & Hoy, 1998). Self-efficacy stabilizes emotional equilibrium (Bobek, 2002), nullifies self-doubt, increases morale, and neutralizes negative perceptions of inadequacy in job tasks (Reglin & Reitzammer, 1998). Most assuredly, "people who have a strong sense of efficacy to control their own thinking are less burdened by negative thoughts and experience a lower level of anxiety" (Bandura, 1997, p. 149). Controllability, therefore, is the key to teachers' managing their actual capabilities to perform well. When teachers usher in concepts with humor, they gain the confidence to deflect stressors and to appraise themselves positively as teachers.

Humor has "evolved as a cognitive coping mechanism for interpersonal communication that is necessary for survival" (Martin, 2007, p. 105). Suffice to say if recognizing the humor in anxious situations affords teachers control (Morreall, 1997), it is possible for them to manage learning impediments with social humor to maintain their self-efficacy (Bobek, 2002). A developed sense of playfulness and an appreciation for what is funny can summon humor to disarm contention and build group cohesion (Martin, 2007).

All humor is defined by the common psychological characteristic of incongruity, or a sudden shift between two differing states of being (Morreall, 1983). Cognitive processes lead to the perception of incongruity and function when a sudden shift between *schemas*, the mental models developed to store experiences, occurs simultaneously with generated ideas (Martin, 2007). The schematic shift between incongruities is akin to the creative "Aha!" when we suddenly see something new in our mind's eye (Besemer & Treffinger, 1981; Koestler, 1964; Torrance, 1966). For individuals to enjoy a perspective shift requires a willingness to let go of fettering fears. At that moment they are relaxed, engaged, and positively motivated (Torok, McMorris, & Lin, 2004; Martin, 2007). This humor bonus is effective in such subjects as visual arts, that lean heavily on creative generation of ideas. As positive laughter replaces negative anxiety, it sends everyone into risk-taking mode to solve problems—a process inherent to art production (Freda & Csikszentmihalyi, 1995). Aside from generating creativity (Jonas, 2004), humor relaxes inhibitions, alleviates worry, relieves pain, abates illness, sustains morale, preserves hope, and elevates self-respect (Martin, 2007).

One of the most desirable outcomes of humor for educators is the potential for establishing student rapport quickly to relax the learning environment so that ideas are free flowing (Gorham & Christophel, 1990). Students respond well to humorous teachers because the teachers are equipped with emotional intelligence that makes them attentive (Sala, 2003), caring (Glasser, 1997) usually cheerful (Bobek, 2002), comfortable with themselves (Wrench & McCrosky, 2001; Svebak, 1974; Ziv, 1984), emotionally stable (Gorham & Christophel, 1990; Wanzer & Frymier, 1999), able to make learning enjoyable (Berk, 2002), and memorable (Korobkin, 1988;

Martin, 2007; Opplinger, 2003; Torok et al., 2004; Ziv, 1988). Perhaps the most compelling concept that is yet to be explored is the emotional capacity that pedagogical humor shares with teacher self-efficacy.

Our teaching efficacy comes from four sources that influence our perceptions: enactive mastery experiences, vicarious experiences, verbal persuasion, and affective arousal (Bandura, 1997). Enactive mastery experiences are successful teaching accomplishments remembered from prior successes with students (Tschannen-Moran & Hoy, 2007). Mastery experiences raise expectations for future performances if the task at hand is similar to ones in past successes. The second source comes from vicariously observing a modeler perform a task well if he or she is one with whom we closely identify. Observing modeled performances in training sessions can convince us that the achievement outcome will be the same for us. Teachers can strengthen their self-efficacy beliefs through a third source, verbal persuasion. Authentic praise offered to teachers by mentors, peers, or staff development leaders powerfully persuades teachers that they possess skills that certify achievement (Tschannen-Moran & Hoy, 2007). This conviction, when accompanied by evaluative feedback, initiates both a positive perception of self and hope for skill development. The fourth source comes from physiological arousal: somatic, emotional, and physiological states that moderate teachers' perception of competence (Pajares, 2002). When teachers are in a good mood, feel physically well, and are in control of their classroom, the perceptions of their capability rises (Bandura, 1997). Conversely, when teachers anticipate incompetence and are unhappy in their jobs, anxiety sets in to bring about perceived failure.

Teachers judge their performance with two internal assessments: what is required to succeed in a task and what resources they possess to apply to the task (Tschannen-Moran, Hoy, & Hoy, 1998). For example, teachers planning to introduce a difficult concept may perceive that they do not possess sufficient skills to help students excel because they recalls past attempts that have failed. Shining performances of the past are linked with a keen sense of pleasure (positive physiological arousal) and drive teachers to repeat what works. Levity and laughter elevate perceptions of success, much like salt in water permits objects to float.

Prior Study Linking Sense of Humor to Teaching Self-Efficacy

The results of the preceding arts-based study capturing quantitative data from K–12 visual art educators ($n = 354$) suggest that high humor orientation holds a positive interaction with instructional efficacy. The study captured participant response on self-report surveys measuring teachers' sense of self-efficacy and humor. Scores on the Teachers Sense of Self-Efficacy Scale, or TSES (Tschannen-Moran & Hoy, 2001), recorded responses on three dimensions of classroom performance: instructional strategies, student engagement, and classroom management. Scores on the Multidimensional Sense of Humor Scale, or MSHS (Thorson & Powell, 1993), captured data on four dimensions of humor: humor creation, social humor, humor used to cope, and humor attitudes (Evans-Palmer, 2010). Teachers rated their perceptions with responses on a scale from 0 (*strongly disagree*) to 4 (*strongly agree*). High scores on either measure indicated a greater overall sense of efficacy or humor.

The final analyses supported a positive, linear relationship between sense of humor and self-efficacy, in line with previous research (Sveback, 1974; Wrench & McCroskey, 2001; Ziv, 1984). Results associated high humor orientation with teachers' high self-efficacy beliefs and observed a moderately significant correlation between the total scores of the self-efficacy and sense of humor measures ($r = .22$, $r^2 = .05$, $p < .001$, two-tailed) with a shared variance of 4.8% (Evans-Palmer, 2010). Positive correlations were found between the combined dimensions of

humor with instructional efficacy and student engagement efficacy. The strongest association linked social humor with instructional efficacy ($r = .29$, $p < .001$, two-tailed), connecting social humor to student achievement (Thorson & Powell, 1993). Essentially this study observed that when scores were high for social humor, humor creation, and humor used to cope, instructional strategy efficacy was also high.

Interestingly, teacher responses for perceived high levels of stress contributed to a decline in instructional efficacy. Responses to the item worded, "I feel stressed in the classroom" ranged from "1 (*never*)" to " 6 (*most of the time*)." A staggering 75% of respondents reported the highest levels of stress on the scale *once per class or most of the time*. Regression analyses produced significant relationships among variables in a model with the variables instructional efficacy, social humor, humor creation, humor used to cope, teacher age, years of teaching, and perceived stress ($r = .26$, $r^2 = .067$, $F(7, 339) = 8.81$, $p < .005$) and revealed that the two highest levels of stress (*often stressed* and *always stressed)* made the strongest unique contributions to instructional efficacy. Overall, the findings supported a positive relationship between high humor perceptions and effective instruction, as long as teachers were not highly stressed (Evans-Palmer, 2010).

The sample in this study demonstrated a confidence level of 95.15% and represents demographics comparable to the greater population of K–12 public school educators nationwide in the same year: gender (sample: 85% female, 13% male; national: 76% female, 24% male), age (sample mean: 46 years; national mean: 43 years) and years of experience (sample: 12.5 years; national: 13 years) (Evans-Palmer, 2010). Conventionally in social science research, generalizations can be made from specifics if the sample is random enough to relate conclusions to the larger population. The true test for generalizability of arts-based research may not be merely to convince members of a larger audience with a numerical confidence ratio, but to ask better questions that will broaden the conversation to effect education change across all disciplines (Cahnmann-Taylor & Siegesmund, 2013).

How can the emotional well-being of all teachers be supported so they are able to reach and change the lives of students the way our teachers changed our lives (Palmer, 2007)? Toward this end, the present author examined humor and self-efficacy literatures, identified behavior trait themes, compiled two thematic lists, and then checked the lists for trait similarities common to both constructs. Five distinctive traits or behaviors were identified that influence teacher performances as they interact with students.

Implications for Educators: Five Trait Themes of Efficacy and Humor Behaviors

The thematic intersection of human behavior provides a unique perspective of the social humor that raises instructional efficacy in the classroom socially, emotionally, and cognitively. This discovery proposes that teachers can support effective learning with (a) *social connectedness,* a keen sensitivity to emotional cues, and (b) *emotional intelligence*, the ability to gain immediacy and rapport with students; by confidently maintaining (c) *resiliency to adversity* to override stressors in their working environment; and by believing they are capable of adapting instruction through *(d) self-monitoring* to match mitigating factors in the classroom. Finally, they believe that the learning environment in their class nurtures compelling, original, and innovative ideas, or *(e) divergent thinking* that supports successful learning experiences. See Figure 1.

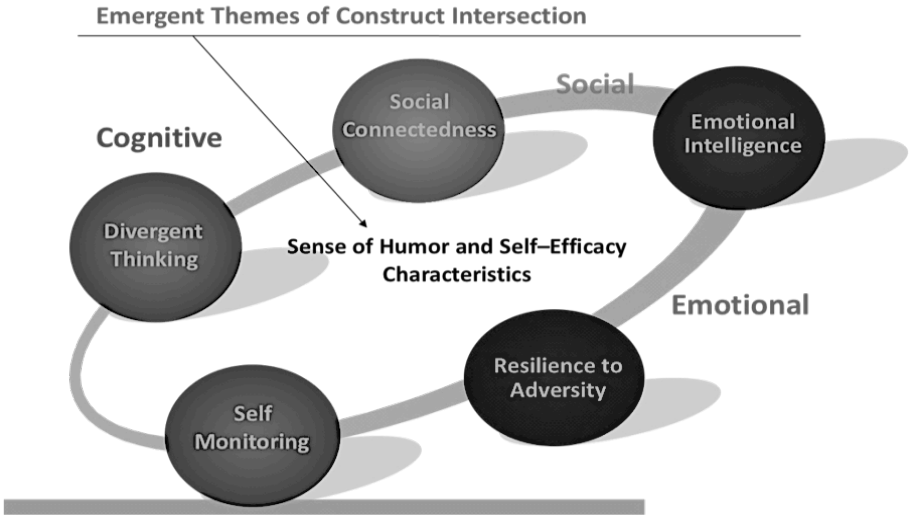

Figure 1. Five behavior traits of teacher self-efficacy and humor.

Social Connectedness

The communal environment that exists in a classroom has the potential to impact the learning that happens there. Unity that springs from group connectedness fosters an empathetic bond, encourages positive, free-flowing interaction, and maximizes retention (Berk, 2003; Dwyer, et al., 2004; Fassinger, 2000; Sidelinger & Booth-Butterfield, 2010).

It is the role of teachers to promote connectedness in a learning environment, but this capability relies heavily on teachers' personality and their sense of efficacy (Bandura, 1997; Marzano, 1992). If effected, a natural connection to the content happens (Downs, Javidi, & Nussbaum, 1988).

When teachers are wholly invested in the act of teaching, they are able to successfully join self and students to bring the subject to life (Palmer, 2007). The connections made by good teachers spring not from their methods but from their hearts, where intellect, emotion, and spirit converge in the human self (Palmer, 2007). Empathetic connectedness to self and others is most naturally conjured up in disciplines where discussion around products of art, music, or literature builds an empathetic community (Bresler, 2006). Shared empathy borne by meditative reflections unwraps rich, interactive dialogue that far exceeds stilted formalistic discussions (Jeffers, 2009). Shared criticism, specifically, commands a triadic connection between teachers and students, students and objects of discussion. Humor that saturates classroom relationships with immediacy or rapport also has the capacity to reduce the psychological distance between teachers and students (Martin, 2007). Low-inference behaviors, such as smiling, speaking with expression, praising students, joking, and using personal anecdotes, establishes bonds with students (Andersen, 1979; Gorham, 1988; Martin, 2007; Torok et al., 2004). By laughing together, teachers and students create a relaxed state from rigorous constraints (Davies & Apter, 1980; Glasser, 1997; Morreall, 1997).

The interrelationship of high efficacy beliefs, high humor orientation, and high immediacy behaviors advances human connectedness; and they influence one another with a kind of cyclic relay effect. A university study (Gorham & Christophel, 1990) revealed that teachers with high immediacy and high self-efficacy used 63% more humor than low-immediacy teachers.

Engaging teachers are skilled at making learning tasks fun. When learning is fun, student perception of teacher competence rises. Quite possibly, students' perceptions of teachers who make them laugh could be the affective catalyst that triggers raised teacher instructional efficacy!

Empirical examination of connectedness as it relates to students and teachers in classrooms, albeit meager, supports the idea that a productive community elicits member comfort with differences (Congdon, 2011). Enter, humor. Laughter relaxes factious social protocols when members in a group display emotions with empathy as a mirror matching mechanism (Gallese, 2003; Martin, 2007). Sharing personal anecdotes allows teachers to be [emotionally] vulnerable (Jeffers, 2009). When teachers entertain playfulness, they set free positive emotions that support morale and group cohesion. Conversely, teachers disperse group unity when they protect themselves from emotional stress that lowers their sense of efficacy (Bandura, 1997; Pajares, 2002). Teaching competence is derailed when teachers simply do not believe they can inaugurate a connected community of learners.

Emotional Intelligence

Comparatively speaking, emotionally intelligent teachers are aware of what is happening internally as they experience life (Palmer, 2007). They are sensitive to emotional cues in their classrooms and "perceive, assess, and express emotions," as well as "generate feelings when they facilitate thought" (Salovey & Sluyter, 1997, p. 10). An extraordinary sensitivity to the emotions of self and others defines emotional intelligence and is a veritable cache of good things for teachers (Goleman, 1995). It expedites knowledge of the subject, the students, and themselves as confident, dedicated teachers. This plays out in a classroom instruction much like baseball. At first base, teachers pick up emotional cues from students (Martin, 2007). At second base, they monitor the trajectory of a lesson by matching their behavior to the receptivity of their students. On third base, they proceed with instruction that they have customized for that moment in the classroom. The result is a proverbial home run, and teachers' perception of their teaching success (mastery experience) is heightened. To be sure, elevated self-efficacy perceptions of the emotionally intelligent teacher are arguably more effective than those who are less emotionally intelligent.

When emotional intelligence functions in tandem with a high sense of humor, it boosts a teacher's ability to self-monitor and efficiently manages the sending and receiving of humor (Sala, 2003). Everyone has enjoyed a speaker who confidently sprinkles mind-numbing content with sparkling humor to keep listeners engaged. Not only do people enjoy the lecture, but they also feel connected to the speaker and are better able to retain the information that makes them laugh. Gifted speakers, comedians, and teachers possess an agility to discern the emotional mood of the audience (emotional intelligence) and step up engagement with humor (social humor). They elicit the positive emotions in people that are stimulated by humor-related mirth and significantly moderate interpersonal relationships (Shiota, Campos, Keltner, & Hertenstein, 2004).

The Evans-Palmer (2010) study underscores the interrelation of emotional intelligence to both self-efficacy and sense of humor. Both operate with the capability to gauge which instructional or humor strategy works best, with whom, and when (Jonas, 2004; Wanzer & Frymier, 1999). The correlation for humor creation and instructional efficacy ($r = 27$, $r^2 = .073$, $p < .001$) suggests a reasonable intersection of emotional intelligence at the constructs of humor and self-efficacy. Emotionally intelligent teachers often initiate humor to ignite classroom

instruction. Their sensitivity to student response permits them to pick up emotional cues needed to generate humor and to teach effectively.

Resilience to Adversity

No task is insurmountable for teachers with high self-efficacy beliefs. They boldly plow through the morass of classroom tasks with little regard for failure. Quite simply, when effective teachers encounter barriers, they create barrier-jumping solutions. They take another route, find another resource, adjust, and leap forward. Teachers with high self-efficacy beliefs are not easily discouraged by failure. They are convinced that problems serve as life's crucible for strengthening character and rebound from setbacks with tenacity, determined to reach their goals (Pajares, 2002). Spirited, competent teachers step over stressful problems and regain emotional balance more quickly than fragile, low efficacy teachers who focus on relieving their emotional distress (Pajares, 2002; Schonfeld, 2001). Highly effective, resilient teachers seek out resources and adapt instruction to help all students achieve their very best. These teachers chalk up a number of successful mastery experiences that raise their perceptions of efficacy even higher and lead to greater commitment to teaching (Yost, 2006).

This article proposes that a sense of humor optimizes the positive point of view of highly effective teachers, but it is known that teachers often make mistakes. When teachers can laugh at their own foibles, it shows students how courageous humor helps people cope with embarrassment. An ability for students to enjoy a joke at their teacher's expense models learning as a process of trial and error, stumble and recovery. Everyone fails at some point, and making mistakes is a process inherent to production of creative products. Highly efficacious teachers should feel safeguarded against failure and more willing to take risks (Freda & Csikszentmihalyi, 1995).

The Evans-Palmer (2010) study recognizes that teacher perceptions of elevated stress, when controlling for age and experience, predict a diminishing belief in their capability to engage students and teach effectively. Three-quarters of the art teachers in the sample reported that they often felt stressed (59%) or always felt stressed (16%) in their current teaching assignment. The correlations with stress and both humor and efficacy variables maintain that stress may adversely affect teacher performance; but the higher teachers' sense of self-efficacy, the greater their resilience to stress (Pajares, 2002). Even while operating in a negative emotional state, emotional relief is always within teachers' reach. When teachers laugh with students (regardless of teachers' age, perceived stress, or years of teaching), they promote a positive climate that displaces anxiety with pleasure (Evans-Palmer, 2010; Morreall, 1997).

When humor is called upon to counteract the negative effects of stress, positive emotions accompanying humor serve to moderate menacing situations (Martin, 2007). The present author can attest to the value of humor with an example from the past. A student in the author's high school art class clearly detested art. The more the student was anxiously prodded, the more the student retreated with angst. On the day before the author had planned to introduce watercolor techniques, the student was overheard expressing a love for listening to Motown groups like the Temptations. The next day, the author prepared a table, easel, paint, and cued-up song, "My Girl.". When the student walked into class, the author picked up the brush and began painting on an easel. Turning to the student, the author chortled, "I've got sunshine on a rainy day, and when it's cold outside...." Without missing a beat, the student smiled and said, "I've got the month of May!" The author hit the player and handed the student the brush, and student and author painted together while chuckling to the music. Laughter had set them both free.

Self-Monitoring

Pajares (2002) proposed that the manner and degree to which a teacher self-regulates behavior depends on the accuracy and consistency of the ability to self-observe, self-judge, and self-evaluate. In the same way that self-monitoring comes to the rescue of comedians recovering from pathetic applause for a weak joke, self-monitoring guides the efficacious teacher in humorous instruction that reaches indifferent students. The synergy of self-efficacy, self-monitoring, and emotional intelligence is put into action to support both comedian and teacher. A sense of humor empathetically compels the comedian and teacher to monitor the emotional reactions of the audience as feedback to help cognitively match responses to cues (James, Minor, Onwuegbuzie, & Witcher, 2002). The vital processes of humor production and social humor are both functions of an individual's ability to adjust behavior according to listener receptivity. It makes teachers comfortable with laughter and comfortable laughing with their students. Consequently, students are motivated, relaxed, and energized, and the whole learning experience is enjoyable (Martin, 2007). Teachers who conduct classes with a sense of play gain strong beliefs in their instructional efficacy (Evans-Palmer, 2010). It would seem that their ability to "read the room" and gauge the receptivity of their students assists effective teachers as a sort of emotional calibration. They can then make sure that the content message they hope to deliver is aimed at the bulls-eye. In the case of the comedian, the bulls-eye is hit when a punch line triggers guffaws. With the teacher, the bulls-eye is a successful connection with students that imparts knowledge. In both comedian and teacher, elevated efficacy occurs.

Divergent Thinking

Clearly, there is an advantage to humor in instruction for the contribution it makes to creative thinking. The essence of creative, divergent thinking is the ability to perceive situations from various points of view (Pollack & Freda, 1997). Divergent thoughts abound in a sort of imaginary playground of the mind and are especially salient in classes where the generation of original ideas is anticipated. The moods and feelings of affective states (physiological arousal) function with self-efficacy and have been shown to moderate creative, divergent thinking (Ashton-James & Chartrand, 2009; Fredrickson, 2001; Greene & Noice, 1988; Mraz & Runco, 1994).

In the best of situations, a teacher inspires students to risk failure as they hurl toward ingenuity with compelling, original, and innovative ideas (Anderson & Milbrandt, 2005). In truth, several elements are joined together to make divergent thinking happen: a humorous, playful perspective incites divergent thoughts that generate alternatives to solve problems and lead to original creative responses. In the worst of situations, instruction is dominated by parameters to raise standardized test scores and does not encourage divergent thinking (Halayna, Nolen, & Haas, as cited in Chapman, 2007) but seeks to drive home the right answers in the same way that test items elicit responses on standardized tests.

Instruction in innovation, especially, develops creative problem-solving skills that the new generation of workers will need to function in a world of unknowns tomorrow—workplaces of the 21st century and beyond. Society points to its pioneering educators to teach creative, divergent thinking. With enhanced creativity, teachers see problems as potential and not obstacles, and challenges as opportunities to generate alternatives for breakthrough solutions. "Look around and see that the innovators among us are the ones succeeding in every arena" (Seelig, 2012, p. 4).

Whether teachers are cracking jokes or solving problems, both activities require the selection of two incongruent ideas. Historically, cognitive theories have emphasized the value of humor-related thinking and the contrast of congruent ideas. Not surprisingly, laughter is shown to assist the brain in the functions of both cerebral hemispheres and produces a level of mental processing that is unmatched by solemn instruction (Sveback, 1974). When mental incongruity functions with humor to leap into the unknown for advancing incongruity resolution, humor serves as a safety net to deactivate fear of failure. The freedom to fail may be one major catalyst of creativity, and an exemption from failure can generate free-flowing ideas that exceed any expectations we may have for attaining ingeniousness (Shade, 1996).

Humor, the most significant behavior of the human brain, sparks the reconfiguring of perceptions, the essence of creativity (DeBono, 1993). Original ideas that are provoked by divergent thoughts are akin to both problem solving and humor creation; both operations involve selection of two incongruent ideas. Once the perception of incongruity is established, cognitive play is set in motion toward creative thoughts (Crocco & Costigan, 2007). Information that is based upon experiences is stored in the brain as *schemas* (Martin, 2007). When unrelated, incongruent schemas are brought together in a single idea, it is "called *bisociation*, and is an operation of both artistic invention and humor creation" (Morreall, 1997, p. 114). One effective strategy that maximizes creative thinking is brainstorming. Good brainstorming with a group sets inhibitions free and generates a wealth of alternative solutions to problems (Freda & Csikszentmihalyi, 1995). When humor is present in the mix, ideas that are unusual, absurd, and seemingly incompatible (many of which seem incongruent) come tumbling into the equation (Freda, Fry, & Allen, 1996).

Creativity that thrives with fertile humorous instruction not only helps students to leap into creative endeavors, but assists teachers in raising their perceptions of instructional efficacy. In support of this concept, the study by Evans-Palmer (2010) observed moderate correlations with instructional efficacy, overall Multidimensional Sense of Humor Scale (MSHS) scores ($r = .27$, $r^2 = .07$, $p < .001$), and humor creation scores ($r = .27$, $r^2 = .07$, $p < .001$). Employing the requisite skill for creating humor, in the context of instructional content, could make lessons more memorable. Memorable content enhances student achievement, which in turn precipitates a rise in instructional self-efficacy, and thus a cycle for learning is set in motion.

Conclusion

This article endorses affirming humor in instruction to sustain teachers' belief in themselves as good teachers. Teachers with a high sense of humor and those with strong beliefs in their capabilities perform well and feel good doing it. They possess heightened emotional, cognitive, and affective capabilities. They are divergent thinkers who are socially connected. They are innovative, flexible, resilient, and able to motivate their students. They face their problems with optimism, working hard to seek solutions. Their teaching methods engage, motivate, and clarify content.

Glasser (1997) argues that good comedians are always good teachers, but how do teachers approach good teaching with good humor? The process must begin with pre-service teachers who wrestle with "classroom management problems that overshadow novices' instructional focus" (Burkman, 2012, p. 28). National standards for teacher preparation emphasize affective disposition assessment of teacher candidates (Klein, 2008), but dispositional evaluations do not consider sense of play or sense of humor as key themes to developing resilience to stress.

Additional "research is needed to document effective professional development for the novice teacher and further develop leaders to effectively communicate with administrators and policymakers" (Borman & Dowling, 2008, p. 9).

Nurturing the affective states of experienced teachers is irrefutably as important. Enhancing teachers' performance has long been the focus of educational policy makers, and researchers have expressed a keen interest in correlational studies of teachers' efficacy tied to personal variables (Tschannen-Moran & Hoy, 2001). Correlations among teachers' sense of humor, their instructional self-efficacy, and classroom stressors underscore the effect of efficacy beliefs on teacher performance over the course of a career. The contribution levity makes to job satisfaction appeals to a critical call for affective support of all educators.

Undeniably, there is research to be done to facilitate understanding of efficacy beliefs among teachers in all stages of service in their profession. The National Art Education Association (NAEA Research Commission, 2008) report of research needs recounted the topics most frequently rated as "highly important" or "very important": teaching (88.7%), instructional contexts (82.9%), and teacher preparation (80%). Membership advocated for professional development and leadership training in a variety of contexts and could reinforce the behavior traits in this article. It is possible to boost emotional intelligence. The Emotional Intelligence Scale (EIS; Schutte et al., 1998), a scale that produces a global score on perceived emotional intelligence, can identify teachers at risk for poor performance on tasks that require emotional intelligence (Chan, 2003). Those identified with low emotional intelligence (EI) scores may benefit from professional support to heighten emotional intelligence. Perhaps a professional partnership of teachers with low EI scores paired with high-EI-scoring teachers would be effective if adaptive behavior training is modeled (vicarious experience) in a directed program format (e.g., Greenberg, 2002) that offers both training and performance feedback.

Training formatted in collegial teams to develop instructional humor methodology and raise self-monitoring awareness with other teachers may have a resounding effect on collective teaching self-efficacy. Such sessions would raise morale, marginalize perceptions of stress, and maximize instructional efficacy. Assuming that self-efficacy scores rise when humor scores rise does not require teachers to reach for the comic shtick of Robin Williams but encourages them to espouse a playful disposition to deliver content with humor (Berk, 2003).

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Mathematics Instruction

Mathematical Modelling as a Teaching Method of Mathematics

Michael G. Voskoglou

Abstract
This paper analyzes the process of mathematical modelling as a tool for teaching Mathematics, through which students can understand the usefulness of mathematics in practice by connecting it with real-world applications. Further, methods for assessing students' mathematical model building skills are presented (calculation of the means, GPA index, COG defuzzification technique) and compared to each other through a classroom experiment performed recently with students of the School of Technological Applications of the Graduate Technological Educational Institute (T. E. I.) of Western Greece.

Key Words
Teaching mathematics, problem solving, mathematical modelling, students' assessment, GPA assessment index, COG defuzzification technique

Abbreviations
PS = problem solving, MM = mathematical modelling, FL = fuzzy logic, COG = center of gravity, GPA = grade point average

Introduction

From the origin of mathematics there exist two extreme philosophies about its orientation (presentation, teaching, research, etc.): The *formalistic–productive*, where emphasis is given to the content, and the *intuitive–inductive*, where the attention is turned to problem-solving processes (Voskoglou, 2007a). According to Verstappen (1988), there is a continuous oscillation in mathematics between these two extreme philosophies. This oscillation is symbolically sketched in Figure 1, where the two straight lines represent these two philosophies, while the continuous broadening of space between the lines corresponds to the continuous increase of mathematical knowledge. A similar perception has been supported earlier by Davis and Hersh (1981).

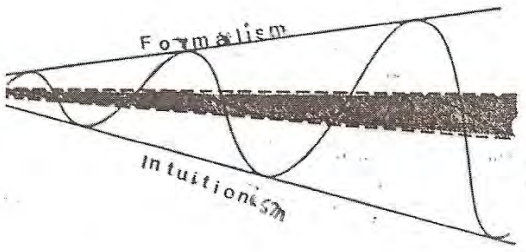


Figure 1. The oscillation in mathematics education.

Examples of how the "mathematics pendulum" swung from one extreme to the other over the span of about a century include the evolution from the mathematics of Bourbaki to the reawakening of experimental mathematics; from the complete banishment of the "eye" in the theoretical hard sciences to computer graphics as an integral part of the process of thinking,

research and discovery; and also the paradoxical evolution from the invention of "pathological monsters," such as Peano's curve or Cantor's set—which Poincare said should be cast away to a mathematical zoo never to be visited again—to the birth of a new geometry, Mandelbrot's (1983) Fractal Geometry of Nature.

In the field of Mathematics Education, the failure of the introduction of the "new mathematics" in school education (e.g., see Kline, 1973) placed the attention of specialists on the use of the problem as a tool and motive to teach and understand better mathematics. The perceptions of this movement are mainly expressed through *problem solving* (PS), where attention is given to the use of the proper heuristic strategies for solving mathematical problems (e.g., see Voskoglou, 2012), and *mathematical modelling (MM) and applications*, i.e., the solution of a particular type of problems generated by real world situations (e.g., see Voskoglou, 2011a).

The target in the present paper is to study and analyze the MM process as a method of teaching mathematics and to present traditional and fuzzy logic methods for assessing students' MM abilities. The rest of the paper is organized as follows: Section two reviews the development of MM as a tool for teaching mathematics from the 1970s until nowadays. Section three discusses the connections of MM with fuzzy logic (FL), while section four presents methods of assessing students' MM skills and compares them to each other through a classroom experiment performed recently at the Graduate T. E. I. of Western Greece. Finally, section five is devoted to final conclusions and a brief discussion of plans for further future research on the subject.

The Circle of Modelling

The notion of a *system* has a very broad context. Roughly speaking, it can be defined as a set of interacting components forming an integrated whole. Examples of systems include the physical systems—the Earth, our solar system, the whole universe, etc.; social systems—our society, religions, countries and organizations, scientific communities, etc.; economic systems—companies, industries, etc.; biological systems—e.g., human or animal organizations; abstract systems—mathematical, philosophical, etc.; artificial systems designed by humans—buildings, transportation means, etc.; and many others.

Systems modelling is a basic principle in engineering, in natural and in social sciences. When a problem is faced concerning a system's operation (e.g., maximizing the productivity of an organization, minimizing the functional costs of a company, etc.), a *model* is required to describe and represent the system's multiple views. The model is a simplified representation of the basic characteristics of the real system, including only its entities and features under concern. The construction of a model usually involves a preliminary deep abstracting process on identifying the system's dominant variables and the relationships governing them. The resulting structure of this action is known as the *assumed real system*. The model, being a further abstraction of the assumed real system, identifies and simplifies the relationships among these variables in a form amenable to analysis. This process is sketched in Figure 2.

There are several types of models in use, according to the form of the corresponding problem (Taha, 1967, section 1.3.1). The representation of a system's operation through the use of a *mathematical model* is achieved by a set of mathematical expressions (equalities, inequalities, etc.) and functions properly related to each other. The solutions provided by a mathematical model are more general and accurate than those provided by the other types of models. However, in cases where a system's operation is too complicated to be described in mathematical terms

(e.g., biological systems), or the corresponding mathematical relations are too difficult to deal with in providing the problem's solution, a *simulation model* can be used, which is usually constructed with the help of computers.

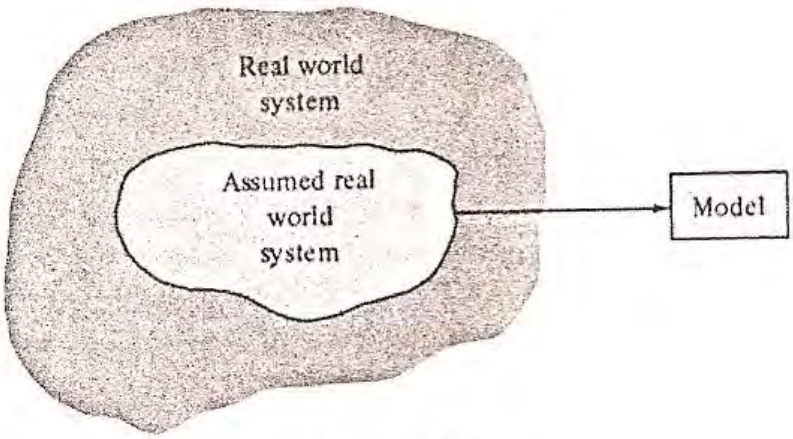


Figure 2. A graphical representation of the modelling process.

Until the middle of 1970s, MM was mainly a tool in hands of scientists and engineers for solving real-world problems related to their disciplines (physics, industry, construction, economics, etc.). One of the first who described the process of MM in such a way that it could be used for teaching mathematics was Pollak (1979), who represented the interaction between mathematics and the real world with the scheme shown in Figure 3, which is known as the *circle of modelling*.

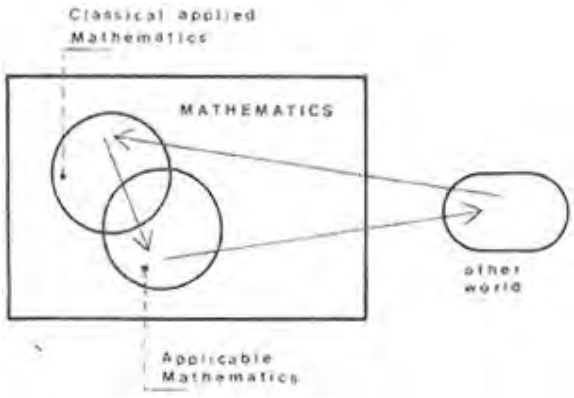


Figure 3. The circle of modelling.

According to Pollak's scheme, in the "universe" of mathematics, *classical applied mathematics* and *applicable mathematics* are two intersected, but not equal to each other, sets. In fact, there are topics from classical mathematics with great theoretical interest, but without any visible applications (although such applications may be found in the future), while other topics

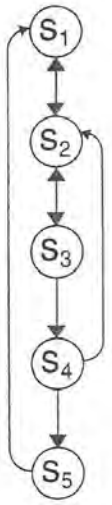
are branches of mathematics with many practical applications, which are not characterized by many people as classical mathematics (e.g., statistics, fuzzy logic, fractals, linear programming, etc.). But the most important feature of Pollak's scheme is the direction of the arrows, representing a looping between the other, or real, world, including all the other sciences and the human activities of everyday life, and the "universe" of mathematics: Starting from a real problem of the other world, we transfer to the other part of the scheme, where we use or develop suitable mathematics for its solution. Then we return to the other world, interpreting and testing on the real situation the mathematical results obtained. If these results are not giving a satisfactory solution to the real problem, then we repeat the same circle again, one or more times.

From the time that Pollak presented this scheme in ICME-3 in Karlsruhe, in 1976, until today, much effort has been placed to analyze in detail the process of MM (Berry & Davies, 1996; Blomhψj & Jensen, 2003; Blum & Leii, 2007; Edwards & Hamson, 1996; Greefrath, 2007; etc.). A brief but comprehensive account of the different models used for the description of the MM process can be found in Haines and Crouch (2010), including the present author's own stochastic model (Voskoglou, 1994, 2007b).

As a result of all the aforementioned research efforts, it is more or less acceptable nowadays that the process of MM in the classroom basically involves the following stages: *analysis* of the problem, *mathematization*, *solution* of the model, *validation* (control) of the model, and *implementation* of the final mathematical results to the real system. Some authors consider further stages in the MM process; e.g., some of them divide mathematization into two stages: the *formulation* of the real problem in a way that it will be ready for mathematical treatment and the *construction* of the model; others divide the validation to the stages of *interpretation* and *evaluation* of the model; still others add the stage of *refining* the model, etc. (Haines & Crouch, 2010). However, all these minor variations do not change the general idea that we use today regarding the circle of MM in the classroom.

As mentioned earlier, the present author introduced a stochastic model for the MM process (Voskoglou, 1994, 2007b, 2011b), in which the MM circle was treated as a Markov chain process, dependent upon the transition between the successive discrete stages of the MM process. The arrows in Figure 4 show the possible transitions between stages.

Mathematization possesses the greatest gravity among all stages of the MM process, since it involves a deep abstracting process, which is not always easily achieved by a non-expert. However, as Crouch and Haines (2004, section 1) report, it is the interface between the real-world problem and the mathematical model that presents difficulties to students, i.e., the transition from the real word to the mathematical model (mathematization) and *vice versa, the transition from the solution of the model to the real world*. The latter looks rather surprising at first glance, since, at least for the type of MM problems usually solved at secondary schools and at the introductory mathematics courses of the tertiary colleges, a student who has obtained a mathematical solution of the model is normally expected to be able to "translate" it easily in terms of the corresponding real situation and to check its validity.



S1: *Analysis* of the problem (understanding the statement and recognizing the restrictions and requirements of the real system.

S2: *Mathematization* (formulation of the problem and construction of the model).

S3: *Solution* of the model.

S4: *Validation* (control) of the model, which is usually achieved by reproducing, through the model, the behavior of the real system under the conditions existing before the solution of the model and by comparing it to the existing (from the previous "history" of the corresponding real system) real data.*

Interpretation of the final mathematical results and implementation of them to the real system, in order to give the "answer" to the real world problem.

Figure 4. The flow-diagram of Voskoglou's Markov chain model for the MM process with states S_i, i = 1, 2, 3, 4, 5. *Note:* *In cases of systems having no past history, an extra simulation model can be used to validate the initial mathematical model.

However, things are not always like that. In fact, there are sometimes MM situations in which the validation of the model and/or the implementation of the final mathematical results to the real system hide surprises that force students to "look back" to the construction of the model, possibly making the necessary changes to it. Reactions by the present author's students in solving the following two problems, when, some time ago, derivatives were being taught, provide a good illustration regarding such situations:

***Problem 1*:** We want to construct a channel to run water by folding the two edges of a rectangle metallic leaf having sides of length *20 cm* and *32 cm*, in such a way that they will be perpendicular to the other parts of the leaf. Assuming that the flow of water is constant, how can we run the maximum possible quantity of the water through the channel?

***Solution*:** Folding the two edges of the metallic leaf by length x across its longer side, the vertical cut of the constructed channel forms an orthogonal with sides x and 32 – 2x (Figure 5).

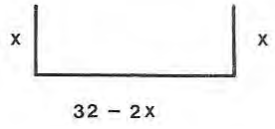


Figure 5. The vertical cut of the channel.

The area of the rectangle, which is equal to $E(x) = x(32 – 2x) = 32x – 2x^2$, has to be maximized. Taking the derivative $E'(x)$ the equation $E'(x) = 32 – 4x = 0$ gives that $x = 8$ *cm*. But $E''(x) = – 4 < 0$, therefore $E(8) = 128\ cm^2$ is the maximum possible quantity of water to run through the channel.

Remark: A number of students folded the edges of the other side of the leaf, and they found that $E(x) = x(20 – 2x) = 20x – 2x^2$. In this case the equation $E'(x) = 0$ gives that $x = 5$ *cm*, while $E(5) = 50\ cm^2$. Their solution was, of course, mathematically correct, but many of them failed to realize that it is not acceptable in practice (real world).

Problem 2: Among all the cylindrical towers having a total surface of 180π m^2, which one has the maximal volume?

Solution: Let R be the radius of the basement of the tower and let h be its height. Then its total surface is equal to $2\pi Rh+2\pi R^2 =180\pi \Rightarrow h = \frac{90 - R^2}{R}$. Therefore the volume of the tower as a function of R is equal to $V(R) = \pi R^2 \frac{90 - R^2}{R} = 90\pi R-\pi R^3$. But $V'(R) = 90\pi-3\pi R^2 = 0$ gives that $R = \sqrt{30}\ m$, *while* $V''(R) = –6\pi R < 0$. Thus, the maximal volume of the tower is equal to $V(\sqrt{30}) =90\pi\sqrt{30} -\pi(\sqrt{30})^3 = 60\sqrt{30}\pi \approx 1032\ m^3$.

Remark: A number of students considered the total surface of the tower as being equal to $2\pi Rh$, not including within it the areas of its basement and its roof. In this case, they found that $h = \frac{90}{R}$, $V(R) = 90\pi R$ *and* $V'(R) = 90\pi > 0$, which means that under these conditions there is no tower having a maximal volume. However, some of these students failed to correct their model in order to find the existing solution of the real problem (unsuccessful transition from the model to the real world).

Examples like the two just presented give the teacher an excellent opportunity to discuss in the class all of their students' reactions (both correct and incorrect), thus emphasizing the importance of the last two stages of the MM process (validation and implementation of the model) in solving real-world problems.

At this point it may be useful to add the following incident: At the end of an announcement that the present author had published in the "MM problems" column in the last edition of the *ICTMA Newsletter* (Voskoglou, 2014b), the following anonymous comment was made regarding the aforementioned water-channel problem: "In the workplace, any product with bends in it require[s] more material to achieve the final design shape than a flat shape of the same size. The angle of the bend also contributes to this. The impact for producing one product is minimal, but when producing thousands[,] the impact is significantly increased. Therefore, more material will be required."

In other words, the author of this comment appears to have suggested a kind of *problem-posing* (e.g., see Brown & Walters, 1990), i.e., starting from the original problem to create a series of similar problems by changing the angle of the bend, etc. Is it a useful comment? Of course it is! This type of problem-posing can be used to challenge over-reliance on the instructor and the textbook and give the students an improved sense of ownership and engagement in their

education. Moreover, extending problems with problem-posing offers other potential benefits. As part of the critical "look back" process of PS, it can enhance student reasoning and the reflection needed for a deep understanding of mathematics. Also, student-generated connections between mathematics and the real world often spring from such creative experiences.

However, as indicated earlier, Problems 1 and 2 were given to the students when the present author was teaching derivatives, and the intention was simply to enrich the lecture with some real-world applications. Imagine now the hypothetical scenario in which a decision would be made to apply the above suggestion in the lecture. It can be stated with confidence that the students would turn their attention from derivatives to the effort of "playing" by creating as many similar problems, as possible!

In concluding, MM appears today as a dynamic tool for teaching and learning mathematics, because it connects mathematics with everyday life, affording students the possibility of understanding its usefulness in practice and therefore increasing their interest in mathematics. In other words, according to Polya's (1963) terminology, MM works as a *best motivation* for learning mathematics. But care must be taken: The process of MM could not be considered as a general and therefore applicable-to-all-cases method for teaching mathematics. In fact, such a consideration could lead to far-fetched situations in which more emphasis is given to the search for the proper application than to consolidating the new mathematical knowledge.

Fuzzy Logic in MM

Models for the MM process, like all those presented in the previous section, are useful in understanding what is termed in Haines and Crouch (2010) as the *ideal behavior*, in which the modellers proceed effortlessly from a real-world problem through a mathematical model to acceptable solutions and report on them. However, life in the classroom—and probably amongst modelers in science, industry and elsewhere—is not like that. More recent research (Borroneo Ferri, 2007; Doer, 2007; Galbraith & Stillman, 2001; etc.) reports that students in school take *individual routes* when tackling MM problems, associated with their individual learning styles and the level of their cognition, which utilizes general concepts that are inherently graded and therefore fuzzy. On the other hand, from the teachers' point of view there usually exists a degree of vagueness about their students' way of thinking in each of the stages of the MM process, when tackling such kinds of problems.

All these inspired the impulse to introduce principles of FL for treating in a more realistic way the process of MM in classroom. For this, the main stages of the MM process have been represented as fuzzy sets in a set of linguistic labels characterizing the students' performance at each stage (Voskoglou, 2010a). Further, the concept of a system's *uncertainty* has been used, which emerges naturally within the broad framework of fuzzy sets theory, for obtaining a measure of students' MM skills (Voskoglou, 2010b).

Here, an alternative approach, commonly used in FL, was applied for assessing students' performance. It is known as the *centre of gravity* (COG) *defuzzification technique* or as the *centroid method* (e.g., see van Broekhoven & De Baets, 2006). According to the COG method, the defuzzification of a fuzzy situation's data is succeeded through the calculation of the coordinates of the COG of the level's section contained between the graph of the membership function associated with this situation and the OX axis.

Several times in the past, Subbotin and others, as well as Voskoglou, either collaborating or independent of each other, have adapted the COG technique for assessing students' skills in a

number of different, mainly mathematical tasks (Subbotin, Badhoobehi, & Bilotskii, 2004; Subbotin, Mossovar-Rahmani, & Bilotskii, 2011; Subbotin & Voskoglou, 2014a; Voskoglou & Subbotin, 2012, 2013; Voskoglou, 2012, 2013; etc.) for testing the effectiveness of a CBR system (Subbotin & Voskoglou, 2011) and for assessing bridge players' performance (Voskoglou, 2014a). In the next section, using similar techniques, the COG method will be adapted for assessing students' model-building abilities, and this approach will be compared with other traditional approaches that can be applied for the same reason.

The only background needed from FL for the understanding of the GOC method is the definition of fuzzy sets (Zadeh 1965), which is recalled here for readers who may be unfamiliar with the subject:

DEFINITION: Let U denote the universal set of the discourse. Then a *fuzzy subset* A of U or *a fuzzy set* A *in* U, is a set of ordered pairs of the form $A = \{(x, m_A(x)): x \in U\}$, defined in terms of a *membership function* $m_A: U \rightarrow [0,1]$ that assigns to each element of U a real value from the interval [0,1].

The methods of choosing the suitable membership function in each case are usually empirical, based either on the common logic or on experiments made on a sample of the population being studied. The value $m_A(x)$, for all x in U, called the *membership degree (or grade) of* x *in* A, expresses the degree to which x verifies the characteristic property of A. Thus, the nearer is the value $m_A(x)$ to 1, the higher x verifies the property of A. The following example illustrates the above definition:

EXAMPLE (The young inhabitants of a city): Suppose that one wants to define the set A of all the young (according to their outer appearance) inhabitants of a city. Obviously the above definition has no clear boundaries, and therefore A cannot be defined as a crisp set. The fuzzy-sets theory has been introduced by Zadeh (1965) in order to cover such ambiguous cases.

In fact, let us consider the set U of all non-negative integers less than 150, representing the humans' ages, as the set of the discourse. Then A can be defined as a fuzzy set in U with membership function m_A given by $m_A(x) = [1+(0.04x)^2]^{-1}$ if $x \leq 70$ and $m_A(x) = 0$, if $x > 70$. Thus, the membership degree in A of an inhabitant aged less than one year is 1, of one aged 25 is $m_A(25) = 2^{-1} = 0.5$, of one aged 70 is $m_A(70) = [1+(0.04*70)^2]^{-1} = (8.84)^{-1} \approx 0.113$, etc.

Each classical (crisp) subset A of U can be considered as a fuzzy subset of U, with $m_A(x) = 1$ if $x \in A$ and $m_A(x) = 0$ if $x \notin A$. For general facts on fuzzy sets, refer to the book by Klir & Folger (1988).

Assessing Students' Model Building Skills

Exploratory investigations have demonstrated how exposure to computers enhances the way students approach MM problems (Asiala et al., 1996; Lewandowski, Bouvier, McCartney, Sanders, & Simon, 2007; Weller et al., 2003; Yadav, Zhou, Mayfield, Hambrusch, & Korb, 2011; Voskoglou & Buckley, 2012; etc.).

In exploring further the effect of the use of computers as a tool in solving MM problems, the following classroom experiment was performed with subjects being students of the School of

Technological Applications (prospective engineers) of the Graduate Technological Educational Institute (T. E. I.) of Western Greece attending the course "Higher Mathematics I" of their first term of studies. (This course involves Differential and Integral Calculus in one variable, Elementary Differential Equations and Linear Algebra.) The students, who had no previous experience with computers apart from the basics learned in secondary education, were divided in two equivalent groups according to their grades obtained in the Panhellenic maths exam for entrance in higher education.

For the control group, the lectures were performed in the classical way on the board, followed by a number of exercises and examples connecting mathematics with real-world applications and problems. The students participated in solving these problems. The difference for the experimental group was that about the one-third of the lectures and exercises were performed in a computer laboratory. There the instructor using the computers presented the corresponding mathematical topics in a more "live" and attractive way, while the students themselves, divided into small groups and making use of a known mathematical software package, solved the problems with the help of computers. Notice that the teaching schedule of the course involved 6 hours per week for both groups, including the time spent in the computer laboratory for the experimental group.

At the end of the term, all students participated in the final written exam of the course to assess their progress. The exam involved a number of general theoretical questions and exercises covering all the topics taught, plus three simplified real-world problems (see Appendix) requiring MM techniques for their solutions. The students' papers were marked in a scale from 0 to 100, separately for the questions and exercises and separately for the problems. Further, their performance was graded as follows: A (90–100) = Excellent, B (75–89) = Very Good, C (60–74) = Good, D (50–59) = Satisfactory and E (0–49) = Unsatisfactory.

No significant differences were found between the two groups concerning the theoretical questions and exercises; their overall performances were almost identical. Following is a presentation and evaluation in detail of the results of the two groups concerning the MM problems. The scores achieved by the students of the two groups were the following, with quantity per score shown in parentheses:

Experimental group **(G_1):** 100(5), 99(3), 98(10), 95(15), 94(12), 93(1), 92(8), 90(6), 89(3), 88(7), 85(13), 82(4), 80(6), 79(1), 78(1), 76(2), 75(3), 74(3), 73(1), 72(5), 70(4), 68(2), 63(2), 60(3), 59(5), 58(1), 57(2), 56(3), 55(4), 54(2), 53(1), 52(2), 51(2), 50(8), 48(7), 45(8), 42(1), 40(3), 35(1).

Control group **(G_2):** 100(7), 99(2), 98(3), 97(9), 95(18), 92(11), 91(4), 90(6), 88(12), 85(36), 82(8), 80(19), 78(9), 75(6), 70(17), 64(12), 60(16), 58(19), 56(3), 55(6), 50(17), 45(9), 40(6).

The preceding data is summarized in Table 1. An evaluation of the aforementioned data will be performed in two ways:

(I) Traditional methods

(a) Calculation of the means: A straightforward calculation provides that the means of the students' scores are approximately 76.006 and 75.09 for the experimental and the control group, respectively. This shows that the *mean performances* of both groups were very good (on the boundary), with the performance of the experimental group being slightly better.

Table 1. *Grading of Student Performance*

Grades	G_1	G_2
A	60	60
B	40	90
C	20	45
D	30	45
E	20	15
Total	170	255

b) Application of the GPA method: It will be recalled that the *Grade Point Average* (*GPA*) is a weighted mean, where more importance is given to the higher scores achieved, to which greater coefficients (weights) are attached. In other words, the GPA method focuses on the *quality performance,* rather than to the mean performance of a student group.
As it is well known from Mechanics, the coordinates (x_c, y_c) of the COG, say F_c, of the level's section F can be calculated by the formulas:

$$x_c = \frac{\iint_F x dxdy}{\iint_F dxdy}, \; y_c = \frac{\iint_F y dxdy}{\iint_F dxdy} \tag{4}$$

For applying the GPA method on the data of this experiment, n_A, n_B, n_C, n_D, and n_E will denote the numbers of students whose performance was characterized by A, B, C, D, and E, respectively, and by n the total number of students of each group. Then the GPA index is calculated by the formula GPA$=\frac{n_D + 2n_C + 3n_B + 4n_A}{n}$. Since GPA = 0 when $n = n_F$ and GPA = 4 when $n = n_A$, we have that $0 \leq$ GPA ≤ 4.

In this case, using the data in Table 1, it is easy to check that the GPAs of both student groups are equal to $\frac{43}{17} \approx 2.529$. This is a satisfactory value for the GPA, since it is close enough to 4. Thus, according to the GPA index, the two student groups demonstrated the same performance.

(II) Application of the COG method (FL approach)

It is considered, as a universal set, the set U = {A, B, C, D, E} of the previously defined linguistic characterizations of the students' performance. The two student groups will be represented as fuzzy sets in U. For this, the membership function m is defined: $U \rightarrow [0, 1]$ for

both groups G_1 and G_2 in terms of the frequencies, i.e., by $y = m(x) = \frac{n_x}{n}$, where the notation for n_x remains the same as for the aforementioned GPA index.

Then, from Table 1, it follows that G_1 and G_2 can be written as fuzzy sets in U in the forms, respectively, of

$$G_1 = \{(A, \frac{6}{17}), (B, \frac{4}{17}), (C, \frac{2}{17}), (D, \frac{3}{17}), (E, \frac{2}{17})\} \quad (1)$$

and

$$G_2 = \{(A, \frac{4}{17}), (B, \frac{6}{17}), (C, \frac{3}{17}), (D, \frac{3}{17}), (E, \frac{1}{17})\} \quad (2).$$

Next is corresponded, to each $x \in U$, an interval of values from a prefixed numerical distribution as follows: E → [0, 1), D → [1, 2), C → [2, 3), B → [3, 4), A → [4, 5]. This actually means that U is replaced with a set of real intervals. Consequently, it follows that $y_1 = m(x) = m(E)$ for all x in [0,1), $y_2 = m(x) = m(D)$ for all x in [1,2), $y_3 = m(x) = m(C)$ for all x in [2, 3), $y_4 = m(x) = m(B)$ for all x in [3, 4), and $y_5 = m(x) = m(A)$ for all x in [4,5). Since the membership values of the elements of U in G_1 and G_2 have been defined in terms of the corresponding frequencies, it obviously follows that

$$\sum_{i=1}^{5} y_i = m(A) + m(B) + m(C) + m(D) + m(E) = 1 \quad (3).$$

At this point, a graph of the membership function $y = m(x)$ can be constructed, which takes the form of the bar graph shown in Figure 6. From Figure 6, one can easily observe that the level's area, say F, contained between the bar graph of $y = m(x)$ and the OX axis, is equal to the sum of the areas of five rectangles F_i , i =1, 2, 3, 4, 5. The one side of each one of these rectangles has a length of 1 unit and lies on the OX axis.

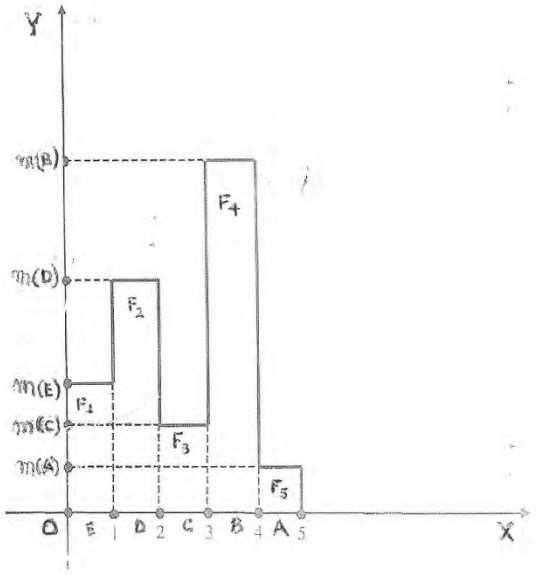


Figure 6. Bar graphical data representation.

Taking into account the data presented by Figure 6 and equation (3), it is straightforward to check (see, for example, section 3 of Voskoglou & Subbotin, 2013, which is available on the web at http://eclass.teipat.gr/eclass/courses/523103) that in the present case, formulas (4) can be transformed to the form:

$$x_c = \frac{1}{2}\left(y_1 + 3y_2 + 5y_3 + 7y_4 + 9y_5\right),$$
$$y_c = \frac{1}{2}\left(y_1^2 + y_2^2 + y_3^2 + y_4^2 + y_5^2\right) \qquad (5)$$

Then, using elementary algebraic inequalities, it is easy to check that there is a unique minimum for y_c corresponding to COG F_m $(\frac{5}{2}, \frac{1}{10})$ (e.g., see Voskoglou & Subbotin, 2013, section 3). Further, the ideal case is when $y_1 = y_2 = y_3 = y_4 = 0$ and $y_5 = 1$. Then, from formulas (5), it follows that $x_c = \frac{9}{2}$ and $y_c = \frac{1}{2}$. Therefore, the COG in this case is the point $F_i(\frac{9}{2}, \frac{1}{2})$. On the other hand, the worst case is when $y_1 = 1$ and $y_2 = y_3 = y_4 = y_5 = 0$. Then, from formulas (5), it can be seen that the COG is the point $F_w(\frac{1}{2}, \frac{1}{2})$. Therefore, the COG F_c of the level's section F lies in the area of the triangle $F_w F_m F_i$.

Then, by elementary geometric observations, one can obtain the following criterion (Voskoglou & Subbotin, 2013, section 3):

- Between two student groups, the group with the bigger x_c performed better.
- If the two groups have the same $x_c \geq 2.5$, then the group with the bigger y_c performed better.
- If the two groups have the same $x_c < 2.5$, then the group with the lower y_c performed better.

Substituting in formulas (5) the values of y_i's taken from forms (1) and (2) of the fuzzy sets G_1 and G_2, respectively, it is straightforward to check that the coordinate x_c of the COG for both G_1 and G_2 is equal to $\frac{103}{34} \approx 3.029 > 2.5$. However, the coordinate y_c is equal to $\frac{69}{578}$ for G_1 and to $\frac{71}{578}$ for G_2. Therefore, according to the aforementioned criterion, and in contrast to the conclusion obtained by calculating the corresponding means, the performance of the control group was slightly better.

Discussion of the Experimental Results

The application of the above—three in total—methods for assessing students' MM skills resulted in different conclusions in all cases! However, this is not an embarrassment at all, since, in contrast to the calculation of the mean which focuses to the mean performance of a student group, the GPA and the COG methods focus on its quality performance by assigning weight

coefficients to the higher scores achieved by students. Further, the COG method is *more sensitive* for the higher scores than the GPA index, since it assigns higher weight coefficients to them. In concluding, it is suggested that the user of the above methods choose the one that fits best for the personal criteria and goals.

Concerning the effect of the use of computers for enhancing students' MM skills that were being investigated with the above experiment, according to the data obtained, it appeared that computer use improved the mean performance of the experimental with respect to the control group. In fact, whereas the GPA index showed that the quality performance of the two groups was the same, the GOC method showed a slight superiority of the control group. In other words, the use of computers enhanced the performance of the moderate students (lower scores), but it had no effect on the performance of the good students (higher scores). An explanation about this could be that the figures' animation, the quick transformations of the numerical and algebraic representations, the easy and accurate construction of the several graphs—especially in the 3-dimensional space—etc., which are comfortably achieved using the computers, increased the moderate students' imagination and helped them in using their intuition more effectively for designing/constructing the solutions of the corresponding problems. Conversely, computer use had not any effect on the good students, who had already developed high MM skills.

Final Conclusions and Discussion

In the present paper, the process of MM was analyzed as a teaching tool of mathematics, and methods were developed for assessing students' model-building abilities. A classroom experiment, performed recently at the Graduate T. E. I. of Western Greece, was also presented, connecting students' MM skills with the use of computers.

Concerning the author's plans for future research on the subject, it must be firstly noted that further experimental investigation is needed in order to obtain safer statistical conclusions about the effect of computers for enhancing students' MM skills. In fact, according to the data of this classroom experiment, small differences appeared between the performances of the experimental and control groups, a fact which, combined with the data of older similar researches, gives only a rather weak indication about the positive effect of computers in enhancing MM skills.

Further, the special form of the COG method that has been used in this paper seems to possess the potential of a general assessment method that could have many other applications in the future on other sectors of human activity besides education. In particular, a recently developed variation of the COG method that has been called *Triangular Fuzzy Model* (Subbotin & Bilotskii, 2014; Subbotin & Voskoglou, 2014b) appears to be very promising towards this direction.

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Appendix
List of MM Problems Used in the Present Experiment

Problem 1: The same as Problem 2, presented in the second section of the paper.

Problem 2: Correspond to each letter the number showing its order into the alphabet (A = 1, B = 2, C = 3, etc.). Correspond also to each word consisting of 4 letters a 2 X 2 matrix in the obvious way; e.g., the matrix $\begin{bmatrix} 19 & 15 \\ 13 & 5 \end{bmatrix}$ corresponds to the word SOME. Using the matrix $E = \begin{bmatrix} 8 & 5 \\ 11 & 7 \end{bmatrix}$ as an encoding matrix, how could you send the message LATE in the form of a camouflaged matrix to a receiver knowing the above process, and how could he/she decode your message?

Problem 3: The population of a country is increased proportionally. If the population is doubled in 50 years, in how many years it will be tripled?

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The Necessity to Reform Mathematics Education in Ukraine

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Abstract
The article makes an argument for the reform of mathematical education in Ukraine. Authors trace the impact of information technologies on the learning process, development, and updating of mathematics software and identify the reasons for this reform. Possible paths of transformation of the math education system are demonstrated, taking into account the harmonious combination of mathematical knowledge and specialized mathematics software; the level of development of mathematics software and its study; update of the curricula by introducing a course, "Computer Mathematics"; use of research approaches instead of computational ones; and formation of cross-disciplinary and extracurricular links in Mathematics.

Key Words
Mathematical education, reformation of math teacher preparation, Computer Mathematics, mathematics software, special courses of Computer Mathematics.

Introduction

The development of the information society impacts education. This impact is observed not only in active equipment of educational institutions with computers, but also in the understanding of the need to rethink conventional approaches to teaching and learning. These factors particularly apply to Mathematics, the classical course of which not only is systematically and fundamentally built but is quite flexible in terms of introduction of modern information support. Such support is in simplification and acceleration calculations, visualization of mathematical objects, and their dynamic change. This cannot be said, for example, about Philosophy, which is an established science whose study has not significantly changed with the involvement of information technologies (IT).

Nowadays we can find a great variety of mathematics software: systems of Computer Mathematics like Maple, Mathematica, Maxima, Sage, etc.; and dynamic mathematics software like GeoGebra, Geometer's Sketchpad, Cabri, etc. These software programs allow rapid solving of problems in various fields of Mathematics, from simple constructions to complex analytical calculations and modeling of processes. A choice of such software is an additional tool for specialists in various fields of Mathematics, in particular, for those who teach Mathematics.

Ukrainian math teachers at secondary schools and universities feel the impact of information technologies and understand the potential that mathematics software carries. Now widespread use of mathematics software in the educational process at school and university is declared in Ukraine. At the beginning of the 21st century, courses for the study of mathematics software were introduced in the curricula of math teacher preparation; and dissertation research for the last 10–15 years has been often focused on the integration of such software in the learning process.
However, analysis of the Ukrainian practice of using of mathematics software in math-teacher preparation, conducted on the basis of existing curricula, materials of scientific-methodical conferences of various levels, and interviews with graduates of different universities, assures that either mathematics software is never used, or some components of different mathematics software are used, or only one mathematics software is used in studying Mathematics. It impoverishes substantive specialist preparation and does not contribute to the formation of the

culture of the use of such software in the teacher's own professional activities. Few, if any, Ukrainian and Russian research works could be identified regarding the use of different mathematics software in teaching of some field of Mathematics. Also in the present authors' opinion, there are few Ukrainian and Russian research works that present approaches to the systematic involving of mathematics software in teaching school Mathematics within one year (5th class, 6th class, etc.).

A detailed study of the research works of the Ukrainian and Russian authors, which are focused on the involvement of such software in the teaching of Mathematics, showed that there is no research devoted to learning the usage of mathematics software in teaching. There are research works focused on solving problems in some mathematics software: Maple, Mathematica, MathCad, Maxima, Sage, etc. Also the present authors identify few research works that demonstrate not the point, but systematic implementation of software in math-teacher preparation.

On the other hand, the study of research focused on the attraction of mathematics software in the process of teaching Mathematics, confirms the relevance of the problem of usage of such software. Researchers such as the following can be mentioned: Bykov, Goroshko, Rakov (Rakov, 2005), Semerikov, Tryus, Vinnychenko, Zelenyak, and Zhaldak in Ukraine; Dubrovsky (Dubrovsky & Poznjakov, 2008), Dyakonov, Martirosyan, Ragulina, and Zhuravlev in Russia; Khrapovitsky (2008) in Belarussia; Hohenwarter in Austria; Althoen and Brandell (2009), King (King & Schattschneider, 1997), Sanders (1994), Schattschneider (King & Schattschneider, 1997), and Scher (2000), in USA; Dimakos and Zaranis (2010) in Greece; and Flores (2010) in Mexico. They mention how to use various mathematics software, and they point to the need to introduce the respective author's methods of teaching Mathematics, which are based on mathematics software and computer-oriented systems of teaching Mathematics, computer-oriented methods of teaching of some topics and sections of school and university Mathematics courses, technologies of electronic, mobile and blended Mathematics teaching, etc.

The generalization of the results of the Ukrainian research works suggests that teachers earlier focused on the process of getting an answer during the teaching of Mathematics; it was important to develop skills to transform and simplify expressions, calculate its value, etc. However, too little time was devoted to study of the answer. After the advent of computer technologies and mathematics software, the process of finding the answer becomes less important, because the computer finds it. The empirical search of laws, the interpretation of results, and a critical look at its application become more important. The present authors believe that this should be the basis of the reformation of Ukrainian mathematics education. Despite the fact that high-quality mathematics education is formed under the influence of good teachers, teacher preparation should be focused on the need to teach the use of mathematics software consciously and rationally in daily life and in future career.

This article will discuss factors that, in the present authors' opinion, should cause the Ukrainian society to move away from the classical ways of teaching Mathematics and to reform the system of mathematics education, consistent with the challenges of the 21st century and at the same time correlated with existing (often overloaded for Ukrainian students) curricula of the school and university mathematics education.

Following are some brief statistics to provide a better understanding of the issues and realities of the Ukrainian mathematical education:

1. The average age of math teachers in Ukraine is about 40 years. (This means that computers were used only in computer science classes during their training at the

university, and they used algorithms that were written in the language BASIC by themselves or in which they used the software Derive for their calculations).
2. The weekly load rate of teachers is 18 hours and not necessarily in the same classes (a teacher can teach at 5th, 8th, and 9th classes).
3. Teachers usually take an overload of 50% because of insufficient living wage (about $150–200 per month).
4. The average age of a university professor is 47–52 years.
5. The load of the university professor is 850 hours per year, of which about 750 are class hours.
6. The average teaching salary with bonuses for a professor with an academic degree and academic title is $250–300.
7. Computer classrooms at schools and universities are used only for Computer Science lessons (they usually are not used for Mathematics lessons).
8. The curriculum has only 8 hours per week for Mathematics in specialized classes and 3 hours per week for humanities classes.
9. The classical course of higher Mathematics (Linear Algebra, Analytical Geometry, Mathematical Analysis) at the university for two years (4 semesters) takes about 800 hours, of which about 300 are class hours.

The Reasons for Reformation of Mathematical Preparation in Ukraine

Economic growth of each country is determined by technological progress and the intellectualization of the main factors of production. The part of new knowledge, that will be implemented in technologies, equipment, personnel qualifications, and production organization in developed countries is 70–85% of GDP growth (Glazev, 2010). This becomes a key factor in market competition: a means of increasing efficiency of production and a means of improving of the quality of goods and services.

An important feature of economic growth is the transition to continuous innovation, based on information technologies. Scientific research and experimental projects, which are implemented by means of information systems, represent an increasing portion of the investment and have already exceeded the cost of purchasing equipment and construction. The abilities to model, think creatively, and use the potential of information technologies become a priority for every person and for the country as a whole. Therefore, the leader in the global economic competition is the one who provides favorable conditions for scientific research and timely coordination of educational policy with modern time.

High-quality education is an important factor of competitiveness of an individual and the country as a whole. This particularly applies to math preparation, which is a strategic resource for the development of the country through the formation of its youths' intellectual skills, creative abilities, and critical thinking. The future of the information society depends on the quality of math preparation, and that is why there are special requirements for its maintenance and improvement.

The real state of math education in Ukraine has been studied. The reasons for changes of methods of math teaching that are associated with the development of information technologies will now be identified.

The First Reason

There is a unique situation in which the computer revolution has brought intellectual work to the priorities of human activity. People with mental actions—to understand the task clearly, to be able to solve it without additional guidance, to be ready for active but responsible involvement of innovations, and to find the time to study constantly and to teach others—have become more valued (Drucker, 2012). These factors cannot be implemented without the mastering of specialized software. According to the forecasts of the world's leading experts, new jobs will require intelligent actions that rely on information technologies. The requirements for qualification and versatility of employees will increase constantly and steadily. It requires *focusing on professionally oriented software and the ability to use it* in solving professional and life goals.

Economists talk about the reduction of the role of industrial and agricultural workers in the countries of Western Europe, the USA, and Japan, and the rapid rise of a new class of intelligent employees who already comprise more than half of the employed population in developed countries (Ministry of Education and Science of the Russian Federation, 2013; Wolfram, 2010). As the Minister of Education and Science of Ukraine S. Kvit noted:

> Today more than 95% of Ukraine economy is 'in the past.' These are the third and the fourth technological structures—ferrous metallurgy, petrochemistry, etc. The modern, the fifth and the sixth levels of technological structure, which, in particular, include information, bio- and nanotechnologies, accounts for less than 5% of the economy. In the world there is a struggle for intelligence. (Kvit, 2014).

Therefore, it can be said that the transition of society to a new stage of its development gives education a task of such *reform of the Mathematics teaching, which is in line with the goals of the computer revolution.* In other words, a system should be organized of math preparation of youth for life in the modern world in the new way; not so much to accumulate Mathematics knowledge, but to operate this knowledge with the production of new knowledge, using Mathematics methods based on the potential of information technologies. Accidental, rare application of mathematics software, which can be seen in Ukraine, is not enough. *The urgent need is to harmoniously combine math knowledge and mathematics software.*

Today mathematics software is not used at Ukrainian village schools or is used only occasionally at provincial town schools (usually Ukrainian software GRAN, which is recommended by the Ministry of Education and Science of Ukraine). This software does not become an adjunctive tool in the hands of young people, because the possibility of its study and use in lessons is limited: schools do not have sufficient number of computers; Mathematics lessons are in chalk-and-board style, without the involvement of computers; not every rural family has the opportunity to buy even a "weak" computer. Classical university Mathematics courses are also often studied without the involvement of information technology (IT). Among the reasons are limited funding for the purchase of licensed software, a limited number of free computer classes, the ignorance of software and its opportunities by older professors. It creates a situation of "discovery" of the existence of mathematics software at the third and fourth years of training; students are surprised to learn that all of the typical problems of Mathematical Analysis, Linear Algebra, Geometry, etc. can now be solved by one command line in the specialized software.

The Second Reason

Now the questions about development—first of all, the ability to think logically on a broad mathematical material (from Plane Geometry to Programming), and *the development of skills for the "real Mathematics"* (meaning Mathematics that occur in everyday life)—are raised.

Often a situation occurs when the students at school or university do not understand why they study one mathematical concept or another, or one mathematical method or another: it seems that Mathematics has only a theoretical mission and has no application to practice (everyday life, real world). Writing complex formulas, young people believe that they study the theory, which they expect never to use in their life. However, most of the processes of the world can be modeled and described by mathematical laws. But this understanding does not come to everyone. School teachers and university professors pay too little attention to the applied aspects of Mathematics, and therefore they do not teach to explore real-world phenomena and to interpret the results. So we have a situation whereby more attention is paid to theoretical and not "real" Mathematics that impoverishes the adequate perception of the youth regarding the surrounding processes, the choice of correct answers in standard and non-standard situations, and the choice of appropriate ways in their own lives.

The Third Reason

A substantial part of the content of the modern Mathematics course should be "Computer Mathematics" as a discipline, which will include a Theory of Algorithms, Mathematical Logic, Probability Theory, Applied and Computer Mathematics, Data Analysis, should appear in Ukraine. Also it is stressed that in the Information and Communication Technology (ICT) environment and with the use of ICT tools (visualization systems, systems of symbolic and numeric computations, etc.), mathematical competence will be developed (Ministry of Education and Science of the Russian Federation, 2013).

Here it should noted that Ukrainian researchers need to evaluate Russian experience and Russian tendencies, because the Russian education system is very similar to that of Ukraine. And although Ukraine has signed the Bologna Declaration, Ukrainian math education is fundamentally not close to European levels. There are many reasons, among which are the limited funding of reforms, the bureaucracy, and the unwillingness of older personnel to change with the times. Therefore, the analysis of the Russian, and not European or American, educational trends allows us to predict the change in priorities of Ukrainian mathematical education in the Ukrainian educational system.

The Fourth Reason

Some research works address the upgrading of certification for graduates. In particular, the USA and Russia propose to use the computer during the independent evaluation of the school graduates. Also it is proposed to move away from the formal tasks found in textbooks, and begin to offer real-life tasks that have a mathematical basis and for which the student can use real tools (smartphones, pads, computers, Internet) (Zhuravlev, 2005; Wolfram, 2010). For Ukrainian education, such thoughts are innovative, but the present authors believe that they should definitely be taken into account. And attention will be paid during studies at school as to the way information technologies can help to solve mathematical problems.

The Fifth Reason

Modern people in their professional activities today cannot imagine themselves outside the information and communication fields, which at the level of the average person are identified with the Internet as a source of finding or consuming data; but it also includes specialized software. That explains the popularity of specialized software that allows the specialists to solve entire classes of professional tasks. Among such mathematics software it is necessary to select the dynamic mathematics software Geometer's Sketchpad, Cabri, Geogebra, etc., which allow you to create interactive mathematical objects and explore their qualitative properties and quantitative characteristics, and also systems of computer mathematics Maple, Mathematica, Maxima, Sage, etc., which contain a huge number of tools for finding the numerical results and the conduct of symbolic transformations, for visual support of the investigated processes, etc.

It would seem that the appearance of such software had to change approaches of obtaining mathematical knowledge, and its usage not only for facilitating the learning process itself, but also for modifying it. In the Ukrainian realities, we continue to face a lack of understanding not only of the main sections of Higher Mathematics, but also of Elementary Mathematics. *Not all graduate students perceive mathematics software as support and at the same time a necessary tool in their own professional activity*. It is clearly traced in the preparation of math teachers: the graduate of a pedagogical university can make a summary of the lessons and present the material in the chalk-and-board style, but, as shown, this individual is not ready to use IT actively in professional activities because of limitations in its technical tools, in training time, in methodological skills to use the software, and so on.

Regarding methodological skills, the present authors studied the causes of this phenomenon and offer the following.

The first cause. Often, a student of a pedagogical university does not perceive the learning material at the proper level. This situation is explained by the following objective factors:

1. Weak training at school—it is no secret that physical-mathematical specialties are not prestigious specialties in pedagogical universities, which get enrollment, as a rule, on the residual principle; only some prospective students, having made a conscious teaching profession choice, have the necessary knowledge and skills in Mathematics to continue their studies at the university.
2. Insufficient "perseverance" of young people or unformed ability to solve problems that require a large number of steps. When a typical problem is presented in 1–3 steps, it is reasonable to expect that it will be solved; but if a larger number of logical links is involved, students often lack understanding of the mathematical fact of the problem).
3. Unformed interdisciplinary and cross-disciplinary links—this trend appeared under the impact of IT, which allows one to find an answer without trying to see the logic solutions, construction, etc.; there is sometimes "painful" dependence on the network—the necessity of the constant presence in social networks (VK, Twitter, etc), the need to use "gadgets" for any search of answers to any question, without critical evaluation of the obtained result, etc.

Solutions to the aforementioned problems are important in Ukraine, and educational science does not offer one recipe for improving the perception of mathematics material. Nevertheless, there are opinions about introducing some new training techniques with higher motivation,

involvement of games or problem situations that can be implemented with the use of information technologies.

The second cause. The development of IT produces a constant software upgrade in Mathematics. If before the mathematics software could give an answer in numerical form only, now it visualizes the progress of solutions. This creates a situation when a student can not only get the answer to some typical mathematical problem (for example, the integral) by the right request, but also get the process of its solution. A typical example of this situation is the "online" integration. The first link on the "integral online" request will display the website help; see Figure 1.

This is a situation in which one should not think enough; one should organize a search on the electronic resource in the right way. In other words, students can get explanations and answers from the Internet.

It is impossible to avoid the use of such resources in Ukrainian realities. Therefore, scientists are forced to revise teaching methods: If before the goal was "to teach to solve a problem," now it is "to formulate a problem," not to find a ready answer in the Internet. But at the same time there were grounds for the formation of mathematical knowledge, because to teach Mathematics without understanding it is impossible.

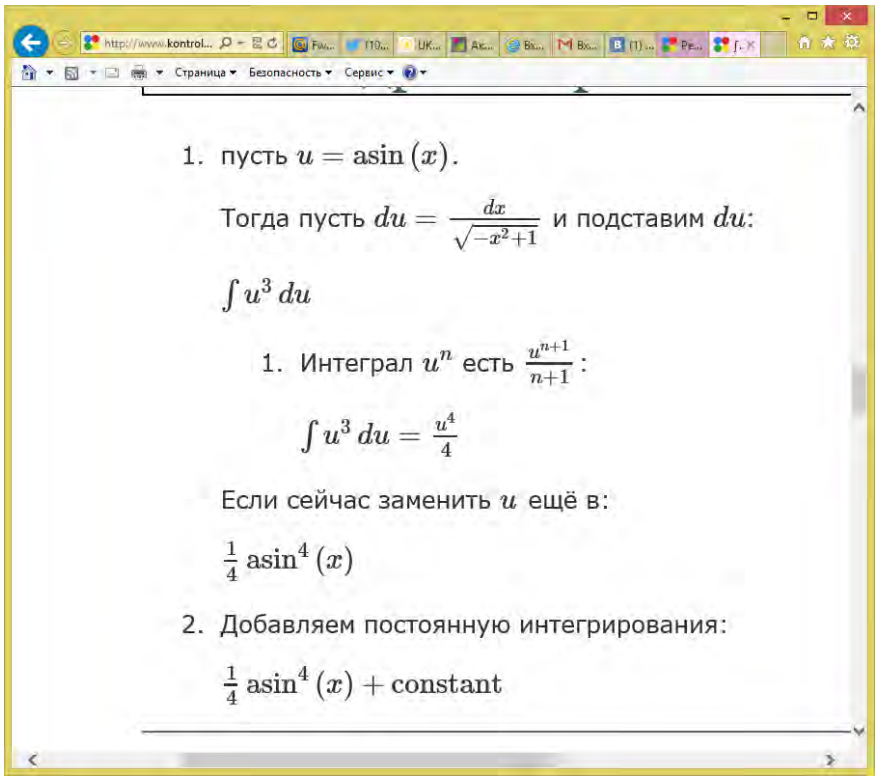

Figure 1. Complete solution of the indefinite integral of functions □□□□□□3(□)1−□2 by online service.

In this context, sensing that the computer (laptop, smartphone, etc.) is an essential tool for student work, the ideas are offered on changing the formulation of typical problems of basic Mathematics courses, on the basis of use of more constructive and not computational approaches, and on the introduction of software. However, the present authors do not believe it is necessary to demand not to use existing software that helps in solving the problems; on the contrary, its use should be encouraged, but at the same time there should be a focus on the adequacy of the given result, the theoretical justification of a proven and disproven fact, and critical evaluation of the possibilities of its further use (Semenikhina & Shishenko, 2013).

As an example, the following situation is offered. At the third year of pedagogical university (in which students have already completed a full course of Higher Mathematics), students are . The students know that it is solved by using the double integral; but forgetting formulas, they use the system of Computer Mathematics: having finite limits of integration on the rectangle, and get the answer "0." It turns out that these surfaces do not form any solid body. The question arises. Students draw (again in Maple) these surfaces and see that the body has a non-zero volume and then start to search for the errors or explain the answer that has been given by the machine. A critical look at getting a computer result is formed.

The third cause. Ongoing reform of Ukrainian mathematical education was reduced to the fact that the classical disciplines did not disappear from the curricula, but their content, specified by the requirements of the standard of education, has ceased to correlate with future professional math teacher preparation. Also the number of classroom hours, when there is a live communication between teacher and youth, decreased, while it is known that formation of professional approaches and methodologies in a future professional teacher is best done through the dialogue. This, in our opinion, *led to the emergence of formalism in the the assimilation and evaluation of educational material. Also this led to teachers' neglecting of tasks, which form stable links between courses of Higher Mathematics and school Mathematics, between mathematical methods and theories and the professional tasks that must be solved in the future by young person.*

This problem has resulted in the emergence of the phenomenon of "discontinued thinking" (Ramskiy, 2013), when the knowledge of graduates does not allow them to pursue professional activities immediately after graduation, does not predetermine their practical actions, and does not serve as criteria and benchmarks for the performance of professional duties. We think that this can be avoided by introducing an integrated course that includes not only the actualization of mathematical knowledge (the level of school and Higher Mathematics) but the demonstration of algorithmic approaches, cross-disciplinary links, etc. Due to the lack of training time, it is possible only with a simultaneous study and the active use of mathematical software.

The Sixth Reason

Traditional education at the Ukrainian university presupposes summarizing the lectures, demonstration of typical examples and problems, and finding solutions of these typical problems manually by students at practical lessons.

Traditional methods of teaching lag behind the methods and approaches of a modern information society, the renovation period of which changes so fast within one generation. Chairman of the Verkhovna Rada Committee on Science and Education Grinevich emphasized that teachers try to teach Mathematics the younger generation of the 21st century by 20th century teachers using the curricula, ideas, and methods of the 19th century (Grinevich, 2013). In other

words, teachers need to tell not so much about the methods of solving problems, which were established yesterday, but to acquaint the youth with the tools that are created today, and methods that are in demand today, to receive more advanced mathematical knowledge tomorrow.

As has been said, today the typical tasks of Elementary and Higher Mathematics are solved through the Internet or by using software, and the youth have the question: "Why should we waste time on this, if we can get an answer immediately, knowing the search tool of this solution?" It is difficult to answer this question, using yesterday's methods of Mathematics preparation: Yesterday the main attention was paid to the process of finding the answer; it was important to be able to count, to simplify, and to convert. If we assume that the main goal will be the ability to make an experiment, analyze the results, model and investigate its properties, etc., then *in conditions of lack of training time the need to use specialized software and the shift of accents in mathematics education must be addressed.*

The Seventh Reason

Mathematics is the basis for many disciplines because it offers useful methods of processing the results. It is more formal itself, and not many see those rich links that continue to multiply in the development of other sciences. This suggests that it is not enough to know only the Mathematics for the modern teacher to be successful; *the teacher needs knowledge from other fields (e.g., Computer Science, Physics, Biology, etc.), which will serve as examples linking the reality with mathematical laws. Today and especially tomorrow, this skill set will distinguish a good math teacher from the rest.* Therefore, the establishment of cross-disciplinary links is one of the key problems of the modern Mathematics preparation. The problem is made considerably easier with the use of specialized virtual laboratories (in Physics, Chemistry, Biology, etc.) and software with the possibility of modeling processes. For example, the following problems will be interesting: the problem of the trajectory of the projectile that is released at an angle to the horizon; the problem of the reproduction of bacteria; the construction of an algorithm for finding roots of equations by the method of dichotomy, etc. All these problems can be modeled by mathematics software. Learning to use this software in the mathematical preparation becomes a necessity today.

The Eighth Reason

A frequent issue in the math specialist's preparation is the lack of skills to use the potential of fundamental knowledge to solve professional tasks. In other words, cross-disciplinary links and extracurricular knowledge are unformed in students; they lack the ability not only to demonstrate skills but to explain why to do something right in this way (Martirosyan, 2010). In the traditional way of teaching, specialized chairs do not distinguish teaching to integrate knowledge as a separate didactic purpose, because they believe that the purpose of study of any discipline, as a rule, is to get (memorize) a certain set of scientific information and then have the ability to handle it. Unfortunately, such outdated approaches still exist in Ukraine. However, the purpose of study in each course is to obtain a complete picture of the knowledge, to get a general understanding of the learning material as representing a professional field, to demonstrate opportunities of transferring the methods of this discipline into other spheres of life, and to provide ways of working with the given knowledge. Mathematics software helps to realize all these ideas today.

For example, the study of statistical methods of evaluating data in the sphere of Pedagogy allows for the analysis of results of the implementation of the new methodology; the results of computer

modeling of a person's reactions to certain impact often cannot be analyzed without knowledge of the trigonometric functions and the concept of extremum; the synergetic concept of "attractor" can be interpreted through the mathematical concept of limit on a certain variety, etc.

The Ninth Reason

At the end of the 20th century, research began that was focused on the introduction of computer technologies in various areas of education (Zhaldak, Horoshko, & Vinnychenko, 2008; Rakov, 2005; Ramskiy, 2013; Zhaldak, Shut, & Zhuk, 2012; Smirnov, 2000; Horokhovatska, 2004; Hrytsenko, 2007). Software in some areas (Mathematics, Physics, Biology, etc.) and the methodical system of its use began to appear. Along with this, a trend was observed toward aging of developed training methodologies focused on this software. Because not only the software is updated, but new technologies of data processing and visualization appear, fundamentally new software is developed that corresponds to the level of technical support of the society and its communications. So, with the appearance of computer mathematics systems such as Maple and Mathematica, the possibility to refuse numerical calculations appears; constant updating of dynamic mathematics software allows talk about geometric experiment and empirical proofs of mathematical statements; visual software allows the building and processing of mathematical models, etc.

Also, there are situations when methodology and guides can be developed for a specific version of mathematics software. Software is updated quite rapidly, and methodological guides for its study expire or are not suitable at all because of changes in software interface, changes in capabilities of software, and/or the inability to install the old version on a new computer or a new operating system. Along with this, old methodological guides are used because of the limited training time, the unwillingness of teachers to improve methodological guides, or the unwillingness of the teacher to study updated mathematics software. All the aforementioned factors prevent full usage of the new version of software and full understanding by students of the modern power of mathematics software.

Therefore, it can be argued that the rapid development of technical equipment of the educational process and computer support in Mathematics requires constant renovation of methods of providing math education. The present authors believe that this update will be better if the level of development of information support in the Mathematics and the recognition of mathematics software, both as objects of study and as learning tools, will become the basis of the instructional methodology with a focus on the foundations of mathematics.

Conclusion

The following factors indicate contradictions between the reality of the Ukrainian Mathematics preparation and challenges of the information society, which requires continuous development of intellectual and creative qualities and mastering of different technologies, including mathematics software:

1. The rapid and constant development of an information society and the technologies it uses.
2. Priorities of intellectual labor, logical and critical thinking, which are formed through the study of Mathematics.
3. The need to attract mathematical arguments and methods in everyday life.

4. The ability to solve many mathematical problems using specialized software.
5. The impact of mathematics software on the study of Mathematics.
6. The experience of global best practices in the use of mathematics software.

The present authors believe that the use of specialized software in everyday life will increase; that is why, among possible paths of renovation of system of mathematical education, approaches are seen that take into account:

1. Harmonious combination of mathematical knowledge and specialized mathematics software.
2. The level of development of mathematics software and mandatory study of it.
3. Renovation of curricula towards the introduction of a separate course of studying "Computer Mathematics," the content of which will include the Theory of Algorithms, Mathematical Logic, and Applied Mathematics.
4. Use of research approaches instead of computation ones.
5. Mandatory formation of cross-disciplinary and extracurricular links in the field of natural and mathematical sciences.

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Education and Business Training

The Nexus between Education and Training: Implications for the Adult Learner

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Abstract
Over the past four decades, the number and percent of adults attending colleges and universities has significantly increased. During this same period, corporate and business training for adult employees has grown to as much as $200 billion a year. Research suggests some important differences between adults and their younger counterparts. Due to extensive research in both higher education and corporate training, it is now clear that our understanding of how adults learn has reduced barriers to their success. This paper will explore the implications of applying educational best practices for adult learners to work-related training, and vice-versa.

Key Words
Adult learners, adult education, corporate training, management training

Introduction

As readers of this journal are well aware, education does not end at age 18, 22, or even 30; for many, if not most, learning is a lifelong endeavor. In a world in which technology is closely tied to economic growth, institutions of higher education are experiencing a dramatic demographic shift in their student bodies. Colleges and universities are increasingly more diverse with regards to race/ethnicity, gender, and age, and many are developing content delivery options to accommodate the numbers of working adults. These same adults may have additional options as well: Larger companies are developing their own in-house universities; many provide ongoing, robust internal training programs, while others regularly contract with professional trainers to try to remain competitive in a changing economy. The authors found it both interesting and surprising that they were unable to find any research that compares best practices of the two largest sources of adult education: higher education and corporate training. This article seeks to fill this knowledge gap.

Over the past four decades, the number and percent of adults attending colleges and universities has steadily and rapidly increased. While overall enrollment in degree-granting institutions increased nearly 145% from 1970 to 2010, the number of students 25 years and older increased over 275%, and those 35 years and older increased nearly 414% (U.S. Department of Education, 2011). In 1970, students 25 years and older accounted for 27.8% of all students enrolled in degree-granting institutions; by 2010, that proportion had increased to 42.6%. The changes in enrollment among students 35 years and older is even more staggering: In 1970, this demographic accounted for only 8.9% of all students enrolled in degree-granting institutions; by 2010, that number had more than doubled, to 18.8%. These trends are summarized in Table 1 and in Figures 1 and 2.

Table 1. *Total Fall Enrollment in Degree Granting Institutions, Shown in Thousands*

	1970	1980		1990		2000		2010		2020 (Projected)	
Age	Qty.	Qty.	% Change	Qty.	% Change	Qty.	% Change	Qty.	% Change	Qty.	% Change
25–29	1,091	1,843	68.9	2,083	13.0	2,044	–1.9	3,196	56.4	3,770	18.0
30–34	527	1,227	132.8	1,384	12.8	1,333	–3.7	1,823	36.8	2,296	25.9
35+	767	1,577	105.6	2,627	66.6	2,941	12.0	3,941	34.0	4,643	17.8
Total (25+)	2,385	4,647	94.8	6,094	31.1	6,318	3.7	8,960	41.8	10,709	19.5
Total (all ages)	8,581	12,097	41.0	13,819	14.2	15,312	10.8	21,016	37.3	24,075	14.6

Adapted from "Table 200. Total Fall Enrollment in Degree-Granting Institutions, by Attendance Status, Sex, and Age: Selected Years, 1970 Through 2020," in U.S. Department of Education, National Center for Education Statistics, *Higher Education General Information Survey (HEGIS),* 2011. Retrieved from http://nces.ed.gov/programs/digest/d11/tables/dt11_200.asp

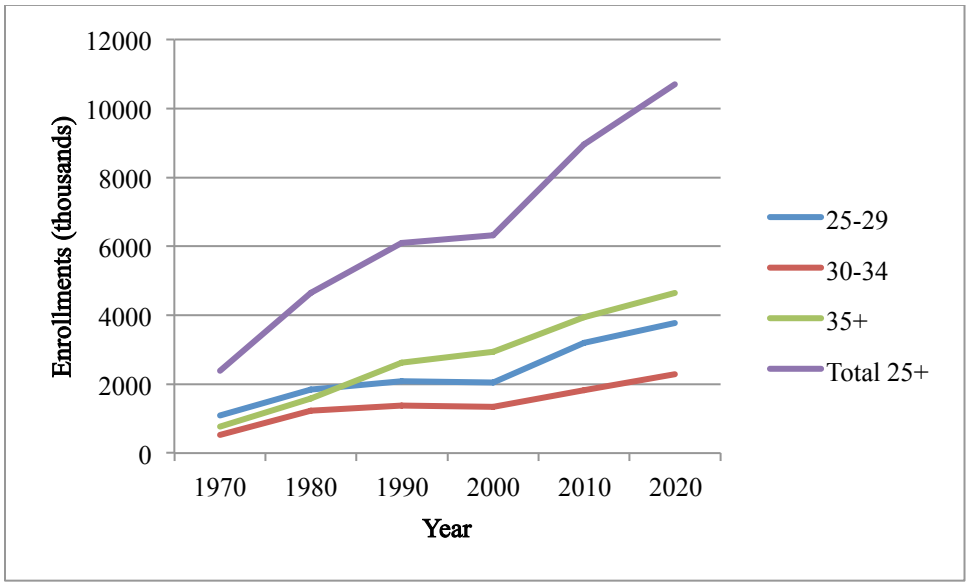

Figure 1. Total fall enrollment in degree-granting institutions (thousands). Adapted from "Table 200. Total Fall Enrollment in Degree-Granting Institutions, by Attendance Status, Sex, and Age: Selected Years, 1970 Through 2020," in U.S. Department of Education, National Center for Education Statistics, *Higher Education General Information Survey (HEGIS),* 2011. Retrieved from http://nces.ed.gov/programs/digest/d11/tables/dt11_200.asp

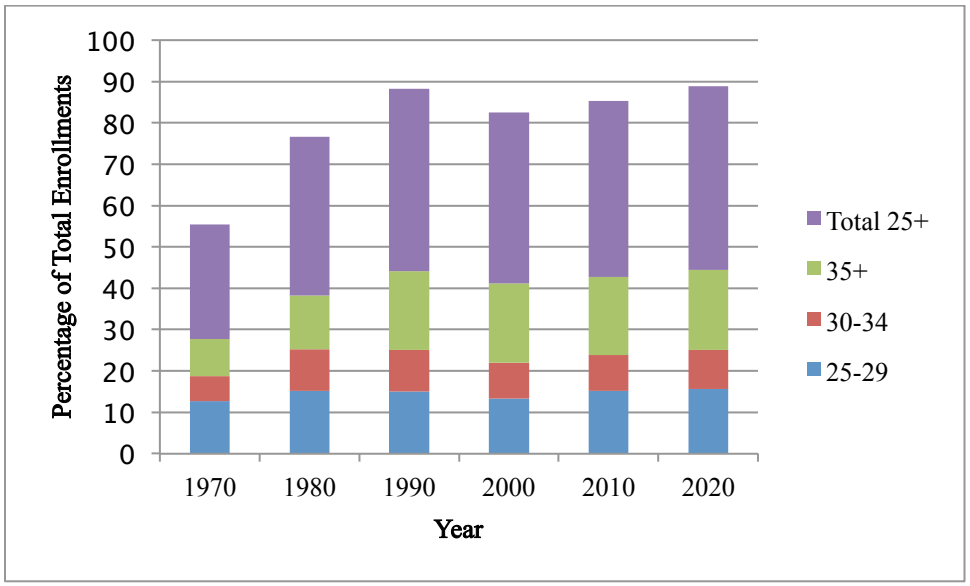

Figure 2. Percentage of total enrollment in degree-granting institutions. Adapted from "Table 200. Total Fall Enrollment in Degree-Granting Institutions, by Attendance Status, Sex, and Age: Selected Years, 1970 Through 2020," in U.S. Department of Education, National Center for Education Statistics, *Higher Education General Information Survey (HEGIS),* 2011. Retrieved from http://nces.ed.gov/programs/digest/d11/tables/dt11_200.asp

Characteristics of Adult Learners

Research on adult learners has utilized a variety of definitions to distinguish this population from their younger counterparts. Knowles (1984, 1990) popularized the term "andragogy" to represent this distinction, describing adult learners as those whom our culture typically identifies as filling adult roles (spouse, parent, worker, soldier, responsible citizen), having more life experiences, and having different motivations and intentionality to learn than their younger counterparts. Adult learners have self-identities of which "full-time student" is just a part (Mancuso, 2001); are self-directed (Brookfield, 1986; Knowles, 1980; Knowles, Holton, & Swanson, 1998; Reid, 1999; Siedle, 2011; Sorcinelli, 1991; Tough, 1966, 1979); have meaningful prior knowledge and experience (Andresen, Boud, & Cohen, 2000; CAEL, 1999; Cross, 1981; Drago-Severson, 2011; Erickson, 1984; Kidd, 1973; Knowles, 1980; Knowles et al., 1998; Mancuso, 2001; Merriam & Caffarella, 1998; O'Connor, Bronner, & Delaney, 2009; Reid, 1999; Sorcinelli, 1991; Thoms, 2001), including what Sheehy (1976) described as "marker experiences" (e.g., marriage, divorce, getting a job, or changing careers), which may provide stronger motivation to learn specific skills or knowledge than younger students. Adults also have a greater capacity for critical reflection (Buskist & Irons, 2009; Connor-Greene & Greene, 2002; Ellis, 2009; Lawrence, Serdikoff, Zinn, & Baker, 2009; Paul & Elder, 2006; Reid, 1999; Siedle, 2011; Wade, 2009) and are more actively engaged in the learning experience (Ausubel, Novak, & Hanesian, 1978; Bichelmeyer, 2006; CAEL, 1999; Cross, 1981; Knowles, 1980; Knowles et al., 1998; Kolb, 1984; Laird, 1985; Mancuso, 2001; Reid, 1999; Sorcinelli, 1991; Thoms, 2001).

Many adults reveal a greater capacity than younger students for focused, intentional learning by making connections between school, work, and home (Bichelmeyer, 2006; Drago-Severson, 2011; Klein-Collins, 2006; Knowles, 1990; Siedle, 2011; Sorcinelli, 1991; Thoms, 2001; Vella, 2002). As a result, adults tend to want to be more involved in designing their learning opportunities (Apps, 1991; Caffarella, 2002; Cervero & Wilson, 1994; Chickering & Gamson, 1991; Drago-Severson, 2011; Falasca, 2011; Galbraith, 1990; Klein-Collins, 2006; Knowles, 1990; Knowles et al., 1998; Laird, 1985; Sork, 2000). This can often mean that adults learn well in collaboration with their fellow students (Drago-Severson, 2011; Klein-Collins, 2006; Knowles, 1990; Sorcinelli, 1991; Stroot et al., 1998), though it is important for instructors to recognize that some may prefer to work on their own (Thoms, 2001).

Of course, not all characteristics of adult learners are conducive to their success in school. There are several ways in which these characteristics can be categorized. For example, Gorham and Christophel (1992), and later Gorham and Millette (1997), identified three sets of factors that specifically affect the motivation of adult learners: context factors (conditions that students bring to the classroom, such as desire to earn good grades and other internal characteristics); structure/format factors (organization of class material, grading, opportunities to participate), and teacher behavior factors (e.g., sense of humor, interest in students, speaking clearly, enthusiasm). (See also Rinne, 1998.) Another model, supported by many researchers (Green & Kelso, 2006), describes two main barriers to adult learning: external or situational, and internal or dispositional. External barriers are typically external to the learner or beyond the individual's control, while internal barriers tend to be associated with personal attitudes, such as thinking one is no longer capable of succeeding in college (Merriam & Caffarella, 1998). External factors can include the environment in which adults learn (Drago-Severson, 2011; Merriam & Caffarella, 1998; O'Connor et al., 2009; Thoms, 2001).

An important internal factor involves learning styles: like all learners, adults learn in different ways. It is probably safe to assume that there is as much variation among adult learners as between adults and younger students. These variations in learning style can be challenging for an adult returning to school after a long absence (Drago-Severson, 2011; Galbraith, 1990; Klein-Collins, 2006; Knowles et al., 1998; Merriam & Caffarella, 1998; O'Connor et al., 2009; Siedle, 2011; Thoms, 2001; Vella, 2002). These differences in learning can be easily extended to how we as individuals give meaning to our experiences; because of differences in our genetics, neurology, chemistry, socialization, experiences, education, etc., we all view the world through different "lenses." How we process and respond to the world around us, reflecting our values, beliefs, and preferences—including prejudices—can provide challenges for adult learners and those who teach them (Brookfield, 2005; Drago-Severson, 2011; Kassin, Fein, & Markus, 2008; O'Connor et al., 2009; Paul & Elder, 2006; Siedle, 2011;Thoms, 2001; Vella, 2002). A heightened desire for course content that is highly relevant to personal and professional goals can also present a challenge to instructors whose students may include a diverse collection of ages, education levels, experiences, races/ethnicities/cultures, and aspirations (Bichelmeyer, 2006; Drago-Severson, 2011; Knowles et al., 1998; O'Connor et al., 2009; Siedle, 2011; Thoms, 2001; Vella, 2002).

Many adult learners, even those with successful careers, are often fearful of failure in the classroom (Cross, 2004; Green & Kelso, 2006; Klein-Collins, 2006; Merriam & Caffarella 1998; Thoms, 2001) and easily demotivated by their instructors (Green & Kelso, 2006). Adult learners are also more likely than younger learners to be concerned about events at home or work, including housing, child care, health care, and transportation (DCHD, MassCAP, &

Commonwealth Corporation, 2003; Klein-Collins, 2006; Thoms, 2001), and these concerns can provide distractions to which instructors must be sensitive.

Implications for Instruction

Current research is very limited regarding the reasons more and more adults are attending degree-granting institutions. Schatzel, Callahan, and Davis (2013) found that 25–34-year-old "stopouts" (students with some college credits who have not attended for one or more semesters) who intend to reenroll are more likely to be younger, to be single, to be a member of a minority group, to have been recently laid-off from work, and to place a high value on education. Merriam and Caffarella (1998) characterize those who actually enroll slightly differently: Typically they are White, middle class, employed, younger, and better educated than adults who do not enroll. Adults who enroll or reenroll in institutions of higher education are motivated to acquire new skills, especially those that are job/career related and that can be put into use immediately (Foley, 2000; Imel, 1998; Klein-Collins, 2006; Knowles, 1980; Knowles et al., 1998; O'Connor et al., 2009; Vella, 2002; Zemke & Zemke, 1984).

However, adult learners tend to be more likely to "stopout" than traditional-aged students (under 24 years), and they are less likely to reenroll once they do (U.S. Department of Education, 1990). These students may have more work and family demands, and may be less prepared to be in school (U.S. Department of Education, 1990). In addition, most institutions of higher education do not collect data on the specific goals of adult learners: It is very possible that that they do not intend to complete an academic degree and that they are enrolling to obtain specific knowledge and skills to advance in their careers and leave schools once they have accomplished those objectives.

Understanding the characteristics and motivations of adult learners has important implications for curriculum design, classroom management, instructional strategies, and even the physical setting (which, as described later in this article, is not limited to a traditional classroom). The following suggestions can be considered "best practices" in adult education:

Colleges and universities can offer introductory and bridge courses (Bash, Lighty, & Tebrock, 1999; Kerka, 1995; Klein-Collins, 2006; Morrell & O'Connor, 2002; Schlossberg, Lynch, & Chickering, 1989; Wonacott, 2001). These courses can provide remediation of basic skills and an orientation to college-level work.

Adults are often interested in designing their own learning experiences, typically in collaboration with the instructor. Many adult learners are self-directed (Drago-Severson, 2011; Falasca, 2011; Galbraith 1990; Imel, 1998; Klein-Collins, 2006; Knowles, 1980, 1990; Knowles et al., 1998; Thoms, 2001; Vella, 2002; Zemke & Zemke, 1984).

Adults prefer active, hands-on learning that involves solving problems and addressing issues that apply to their daily lives (Bichelmeyer, 2006; Imel, 1998; Klein-Collins, 2006; O'Connor et al., 2009; Knowles, 1980; Knowles et al., 1998; Siedle, 2011; Sorcinelli, 1991; Thoms, 2001; Vella, 2002; Zemke & Zemke, 1984).

An effective instructional strategy involves "chunking" material, delivering information in "bite-size pieces," reinforced with practical application (Klein-Collins, 2006; Poppe, Strawn, & Martinson, 2004; Thoms, 2001).

Logically sequencing material (Thoms, 2001) is especially important when learning is more self-directed. Since not all adults learn at the same rate, sequentially organized curricula allow students to advance and or review when they are ready.

Good practice also emphasizes time on task. Most adult learners are focused and want instruction to be efficient. The majority of the adult learner's time should be spent engaged in activities that reinforce intentionality in learning (Bichelmeyer, 2006; Drago-Severson, 2011; Imel, 1998; Knowles et al., 1998; Sorcinelli, 1991; Thoms, 2001; Zemke & Zemke, 1984).

Since adult learners can have a wealth of life and professional experiences, cooperation among students can support course learning outcomes (Imel, 1988; Knowles, 1980; O'Connor et al., 2009; Sorcinelli, 1991; Thoms, 2001; Vella, 2002; Zemke & Zemke, 1984). Moreover, communicating high expectations to learners is an effective method to stimulate performance (Cross, 2004; Siedle, 2011; Sorcinelli, 1991; Thoms, 2001).

While it is an important practice with all learners, it is especially important to explain how content and activities are relevant to the goals of adult learners (Imel, 1998; Klein-Collins, 2006; Knowles, 1980; Knowles et al., 1998; Siedle, 2011; Vella, 2002; Thoms, 2001; Zemke & Zemke, 1984).

Instruction should promote critical thinking in adults who may be resistant to the effort involved (Brookfield, 2005; Buffington, 2007; Buskist & Irons, 2009; Connor-Greene & Greene, 2002; Kassin et al., 2008; Lawrence et al., 2009; Paul & Elder, 2006; Wade, 2009).

Adults have diverse talents, various ways they learn, and various rates at which they learn. It is important to accommodate different learning styles and experiences (Drago-Severson, 2011; Galbraith, 1990; Klein-Collins, 2006; O'Connor et al., 2009; Sorcinelli, 1991; Thoms, 2001).

Prompt feedback and summarization is important to adult learners; they need an accurate assessment about their performance related to learning activities. Adult learners, in particular, should be engaged in self-assessment. Assessing mastery of the learning activities should also recognize differences in learning styles (Bichelmeyer, 2006; Drago-Severson, 2011; Galbraith 1999; Klein-Collins, 2006; Knowles et al., 1998; Siedle, 2011; Sorcinelli, 1991; Thoms, 2001). Adult learners also expect a comfortable environment, including room temperature, seats and desks, and lighting, and they appreciate free food (Klein-Collins, 2006; Thoms, 2001).

More recent research suggests that both online and blended learning are effective methods of instruction with adults (Allen & Seaman, 2005; Bichelmeyer, 2006; Klein-Collins, 2006; Laughlin, Nelson, & Donaldson, 2011; Osguthorpe & Graham, 2003; Rossett, 2006). Team teaching can provide a diversity of perspectives that benefit adult learners (Goetz, 2000; Laughlin, Nelson, & Donaldson, 2011).

Implications for Training

Given the stakes (also known as return on investment) of employee training—estimates of corporate expenditures range from $55.8 billion to $200 billion and are not expected to decrease (Arthur, Bennett, Edens, & Bell, 2003; Bunch, 2007; Martin, 2010; O'Leonard, 2008)—it is not surprising to find a robust body of literature on the subject. In comparison, tuition and fees at four-year Title IV colleges and universities totaled $53 billion in 2012 (Ginder & Kelly-Reid, 2013). Yet given those stakes, training programs are infrequently evaluated on their effect upon on-the-job behavior, or what is generally referred to in the training literature as "transfer of learning" (Alvarez, Salas, & Garofano, 2004; Baldwin & Ford, 1988; Cromwell & Kolb, 2004; Fitzpatrick, 2001; Ford & Kozlowski, 1997; Ford & Weissbein, 1997; Ginder & Kelly-Reid, 2013; Hutchins & Burke, 2007; Yamnill & McLean, 2005). However, the preponderance of the learning transfer literature focuses on training design, trainee characteristics, and workplace environment—and far less on instructor behavior and instructional design (Alvarez et al., 2004;

Baldwin & Ford, 1988; Ford & Weissbein, 1997; Hutchins & Burke, 2007; Saari, Johnson, McLaughlin, & Zimmerlee, 1988; Yamnill & McLean, 2005). The most commonly reported training design involves behavior modeling, practice, and feedback (May & Kahnweiler, 2000; Pescuric & Byham, 1996; Russ-Eft, 1997).

While research on the instructional aspects of training adults is minimal, especially compared to adults in institutions of higher education, there are some parallels. It is likely that corporate and business trainers are not as inclined to publish best practices as college and university professors simply because there is no expectation or requirement to publish; there may also be an element of not wanting to support one's competition (Bichelmeyer, 2006). Moreover, training programs may be proprietary and therefore private. For a variety of reasons, there is evidence of a "research-to-practice gap," a lack of transfer of research findings to training professionals (Hutchins & Burke, 2007; Salas & Cannon-Bowers, 2001).

The gap is manifested in how training resources are distributed and evaluated. As Zenger, Folkman, and Sherwin (2005) suggest, as much as 85% of training resources are allocated to delivering instruction, while 50% of performance improvement is attributed to post-training activities. This discrepancy suggests that the knowledge generated on best practices for working with adult learners in an educational setting has not been consistently applied in the realm of corporate training and the transfer of learning to the workplace (Balaguer, Cheese, & Marchetti, 2006; Hutchins & Burke, 2007; Rivera & Paradise, 2006). Prior to the work of Hutchins and Burke (2007), "there [were] no comprehensive published studies examining training practitioners' knowledge of academic research dealing with factors influencing training transfer" (p. 237).That said, there are some implications for developing effective training programs, including the following.

Assess (diagnose) the current state of the organization and those who will participate in training (Saari et al., 1988; Zillioux, 2011). Based on this assessment, it is helpful to assign pre-work during which learners are asked to think of real work problems on which to focus and to do some pre-learning that will help them begin to generate their own solutions and goals around those problems (Zillioux & Waitley, 2012).

One of the most effective means to increase transfer is to set specific and realistic goals for learning (Brown, 2005; Hutchins & Burke, 2007; Locke, Shaw, Saari, & Latham, 1981; Richman-Hirsch, 2001; Wexley & Baldwin, 1986). Learning outcomes should be developed that allow learners to put new skills to use immediately in ways that are practical; that is, the training information has both content validity (Axtell, Maitlis, & Yearta, 1997) and content relevance (Hutchins & Burke, 2007; Yamnill & McLean, 2005). Research has suggested that training goals and objectives aligned with the mission of the organization are likely to increase transfer (Hutchins & Burke, 2007; Montesino, 2002).

This strategy of goal alignment is consistent with management involvement in establishing goals and objectives for training; in addition to increasing stakeholder investment, this strategy is also effective at modeling engagement and providing encouragement (Baldwin & Magjuka, 1991; Brinkerhoff & Montesino, 1995; Broad, 2005; Clark, Dobbins, & Ladd, 1993; Hutchins & Burke, 2007; Kontoghiorghes, 2001).

Moreover, adult learners want some degree of control over their learning outcomes and experiences (O'Connor et al., 2009). This may be one strategy to help reduce anxiety among learners, which is highly correlated with virtually every training outcome (Colquitt, LePine, & Noe, 2000; Hutchins & Burke, 2007; Machin & Fogarty, 2004).

Learning is not always its own reward, so active, hands-on training is preferable to theory-oriented classes. If repetition is necessary to master a new skill, real world application is more likely to produce learning (Burke et al., 2006; Ford, Quiñones, Sego, & Sorra, 1992; Hutchins & Burke, 2007; O'Connor et al., 2009; Zillioux & Waitley, 2012). One effective strategy for improving transfer is to use multiple, highly variable examples in training (Elio & Anderson, 1984; Hutchins & Burke, 2007; Saks & Belcourt, 2006; Schmidt & Bjork, 1992). Interestingly, this also includes examples of what not to do, or what can go wrong if learners do not correctly apply the training (Hutchins & Burke, 2007; Joung, Hesketh, & Neal, 2006; Smith-Jentsch, Jentsch, Payne, & Salas, 1996). Another strategy is "over-learning" by providing practice of new skills even after learners have demonstrated the new skills (Driskell, Willis, & Copper, 1992; Fisk, Lee, & Rogers, 1991; Hutchins & Burke, 2007).

It is important to develop activities to increase learner self-efficacy, i.e., beliefs about their own ability to perform at a higher level (Gist, Stevens, & Bavetta, 1991; Morin & Latham, 2000). Learning and self-efficacy are also enhanced when new knowledge and skills are integrated with prior knowledge and skills (O'Connor et al., 2009; Zillioux & Waitley, 2012). It can be challenging for those conducting the training to help learners make these connections, so ongoing dialog and assessment are key.

Adults need to be allowed to proceed at their own pace. Self-contained, self-paced learning materials can be an effective means by which to provide these opportunities (O'Connor et al., 2009). Self-pacing also means keeping them engaged and moving, yet also allowing time for reflection (Zillioux & Waitley, 2012). These findings may help explain the results of the meta-analysis by Sitzmann, Kraiger, Stewart, and Wisher (2006), which revealed that Web-based instruction was as effective as classroom instruction in specific domains. Similarly, Bowles (2012) found that for specific types of training, self-study groups using a CD-ROM was found to be more effective than instructor-led groups or self-study groups using printed text.

Be mindful of differences in learning styles, cultural differences, and lines of authority. It is also not unusual to have groups representing multiple generations; understanding how Baby Boomers, Generation Xs, and Millennials view the world is a critical aspect of effective communication (Zillioux, 1995; Zillioux & Waitley, 2012).

Learners should be provided with easy access to information and resources before, during, and especially after the class. A key component to learning is readiness, and being able to access information in a time frame that works for them is important for adult learners. Creating an online repository for training materials is a good way to provide this access (Zillioux & Waitley, 2012).

An element too often missing from training is for trainers to connect with their learners after the learning event to reinforce concepts and assess the degree to which learners are applying new knowledge and skills to work-related issues. Management and peer feedback following training on job performance can also reinforce transfer (Chiaburu & Marinova, 2005; Frayne & Latham, 1987; Gist et al., 1991; Hawley & Barnard, 2005; Hutchins & Burke, 2007; Latham & Frayne, 1989). Following up also allows for further linking the training to business outcomes (Zillioux & Waitley, 2012). However, it is important not to confuse the reactions of the learners to the training (the most common form of assessment of training activities) with transfer success; the relationship between the two measures is negligible (Alliger, Tannenbaum, Bennett, Traver, & Shotland, 1997; Colquitt et al., 2000; Hutchins & Burke, 2007).

Another set of issues, one that in many ways set training apart from formal education, relates to the roles of the adult learners in their organizations. Leaders, managers, and employees will

use their newly acquired skills in different environments; those environments can either support or limit the effectiveness of training.

Conclusions and Recommendations

This review of the literature on adult education and training has revealed some important gaps in the nexus between the two, especially the research-to-training gap. As suggested by Hutchins and Burke (2007), this gap may be greatest in the areas of measuring transfer success and in evaluating best practices related to those outcomes. They further suggested that this gap may be fostered by the lack of publishing research findings across multiple disciplines; specifically, practitioners as less likely to read (and sometimes understand) academic journals, where topics such as instructional strategies and design are evaluated as they relate to adult learners. As a result, one aspect of this "knowledge transfer problem" (Van de Ven & Johnson, 2006) "is the trainers' role and how they are influenced to learn about and use transfer findings in their everyday duties" (Hutchins & Burke, 2007, p. 259). While the literature suggests some important gaps, it is likely that in at least some circumstances the differences may not be as great as they appear. The research on effective methods for educating adult learners is more robust than for corporate and business training. In addition to the possible reasons mentioned earlier, it is also very likely that more attention has been paid to the formal education environment because of the dramatic demographic shifts in enrollment. As more and more adults attend colleges and universities, faculty at those institutions have increasingly turned their research interests towards developing efficacious models that support students' success. Whether fueled by the same curiosity that led many to research-based degrees or working in an environment that promotes "publish or perish," significant numbers of academics are conducting research and disseminating results that directly impact their teaching. While many faculty are engaged in outside consulting and training, anecdotal evidence suggests that most do not carry over the same instructional design and strategies from their classrooms to the business world, further reinforcing the knowledge transfer problem.

While those who conduct corporate and business training have not published their best practices to the same degree as those in the traditional academic world, it is reasonable to assume that many are motivated to be as effective as possible in helping their clients to master new knowledge and skills. In fact, as noted earlier, there are a number of similarities in what are considered best practices in higher education and in training. Most notably, these include active, hands-on, practical learning that targets real problems; capitalizing on the experiences of adults and their internal motivation to succeed; and allowing adult learners some degree of control over what they learn and how they learn it. In addition there are a series of five critical elements to assuring that training is maximally effective:

1. Top management buy-in
2. Follow-through and reinforcement
3. Demonstrating tangible value
4. Strategic integration
5. The four keys to effective learning: (a) setting the context, (b) acquiring new concepts and skills, (c) practicing new behaviors and skills, and (d) applying new skills on the job. (The Ken Blanchard Companies, 2014)

While the training environment does not always lend itself to the variety of strategies shown to be effective among adult learners—training sessions can range from a few hours to several days to multiple sessions spread over months—there are several areas in which training can benefit from the research on adult education. Some implications for training include:

- *Opportunities for basic skill development.* While there may not be interest in or time to pursue basic reading, writing, and math skills, adults attending training may benefit from direct instruction on how to learning specific content, including how to make connections between prior learning and new material.
- *The design of learning opportunities.* This is a logical extension of presenting opportunities for basic skill development. Since it is known that adults like to have input on goal setting and learning, a simple template for designing experiences may result in a feeling of control as well as accomplishment; for example, how to develop outputs, how to measure effectiveness, how to solve problems, etc.
- *Sequencing and chunking materials.*
- *Consideration of using a hybrid, or blended learning model that combines onsite, face-to-face learning with online learning.* Web-based instruction has far more potential than simply serving as a repository for training materials and is in its very early stages as a training method.
- *An awareness that some learners may fear failure.* This can make them reluctant to participate or may be manifested in resistance to change. At the same time, it is important to communicate high standards and reasons for requiring specific content and activities.
- *Staying focused and on task.*
- *Linking theoretical underpinnings of instruction to hands-on, practical activities.*
- *An emphasis on critical thinking.*
- *Regular assessment of student learning, including self-assessment of learning.* It is important to know when instruction is effective and when it is not. It is also helpful to regularly summarize units of instruction.
- *The providing of a comfortable environment in which to learn.* Make sure materials are easy to read; seats are comfortable and organized to facilitate learning; take breaks; control temperature and lighting; and provide food and beverages when appropriate.
- *Utilization of team teaching when the situation allows.*

There is a strong emphasis and understanding within the ranks of the best corporate training organizations that the purpose of training is to change behavior, and to do that there must be a process of "unfreezing" education by shifting the emphasis to place more relevance on "purpose." It is at this point that we see the nexus between formal adult education and training. In both environments it is critical to understand the specific needs of the learner and fully engage them in the processes of instructional design and implementation. Learners must value the purpose of the learning activities, which should be immediately useful and build on their wide array of knowledge and skills. Training, as well formal education, must accommodate different learning styles; provide opportunities for appropriate follow-on activities that are "just in time," available when they are needed and the learners are ready; and utilize a variety of methods to assess the effectiveness of instruction.

It is also important to consider that the most effective environment for training may not be a classroom; this can be said for higher education as well. In some very important ways, education has changed little in the past 2,500 years; yet our understanding of "what works" rarely involves

a description of the instructor as the sole dispenser of knowledge to a captive audience obediently sitting in rows and quietly taking notes. Of critical importance, then, is continually and accurately assessing the most effective and efficient means for learners to accomplish their goals as learners—typically transferring knowledge and skills from the learning environment to some form of practical application.

Sharing best practices can benefit both academics and professional trainers and the adult learners they serve. The former has a rich, robust body of literature that can help inform those who work with adult learners in the workplace. This is especially true in designing Web-based instruction and assessment. The benefits of sharing are far from one sided, however: Most institutions of higher education could benefit from adopting a more hands-on, project-based, practical curriculum. The number of employees who participate in some form of training will continue to grow, especially as understanding increases regarding what factors best contribute to the transfer of learning. Adult enrollments in degree-granting institutions are also expected to increase in coming years. Both educational environments have a large stake in maximizing the learning opportunities for adults by increasing knowledge transfer.

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Technology-Based Teaching and Learning

Technology Integration in the Resource Specialist Program Environment: Research-Based Strategies for Technology Integration in Complex Learning Environments

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Abstract
This study explored the process through which special education teachers transferred technology knowledge to instructional integration. Based on situated learning theory, it utilized design-based research methods to explore how the two-part strategy of participation in community of practice and use of matrices affected perceived value, frequency, and progress toward instructional synthesis. Participants included a convenience sample of 10 resource specialist program teachers. Overall findings indicate qualitative changes in teaching practices due to raised awareness of technology tools, collaboration within community of practice, and increased student engagement. Implications provide improved technology integration strategies for pre-service teacher education coursework and professional development.

Keywords
Assistive technology, community of practice (CoP), resource specialist program, special education, technology integration.

Introduction

Initiating change is challenging within a group where change is the norm. The resource specialist program (RSP) environment functions in a state of continual change due to two overarching factors: (a) the type of learners being serviced and (b) the constant change in policy, procedures, and paperwork due to ongoing changes in state and federal law. These inconsistencies create a unique obstacle for successful technology integration within the RSP instructional environment.

A review of current special education technology integration literature confirms that technology training does not guarantee the transfer of technology knowledge to instructional practices in RSP environments. As such, there is a need to explore effective methods that might change teachers' attitudes, behaviors, and instructional practice for using technology in teaching and learning (Edyburn, 2008; Leko & Brownell, 2009; Quinn et al.,).

Technology Integration Challenges

Within the context of special education, teaching and learning activities must be designed to meet the specific cognitive, behavioral, and physiological needs of the students. Special education services are designed and offered in several different environments, with the resource specialist program (RSP) being one of the most common. In the RSP environment, teachers typically service students on a pullout basis (Zabala & Carl, 2005). Students leave their general education classrooms and go to the RSP classroom in small groups for 30–45 minutes of instruction each day or every few days. RSP teachers instruct small groups of students from different grade levels, with different learning goals, and with a wide variety of learning and behavioral challenges (Edyburn, 2008). Students who receive RSP services spend a majority of the learning day in the general education classroom, where the student is responsible to achieve proficiency in English Language Arts and Math curriculum as measured on district benchmark

English Language Arts and Math assessments and on annual state tests. To address general education academic goals, the RSP teacher is expected to provide intervention activities to help students prepare for district- and state-approved curriculum. By law, the RSP teacher must also provide instruction on specific curriculum and/or behavior goals as described on the student's individualized education plan, or IEP (Blackhurst, 2005). In effect, the RSP teacher must focus on supporting student achievement for district assessments, state tests, and individual student learning goals as specified on the IEP.

The focus on student learning goals causes RSP teachers to be less focused on technology resources that could support student learning (Cuban, 2001; Edyburn, 2009). Constant changes in time, structure, curricular goals, and student learning needs make technology integration within the RSP environment even more challenging (Edyburn, 2009b). Research suggests that technology integration must be as adaptive as the environment itself (Desimone, 2009; Edyburn, 2009a). Planning time, instructional environment, and differences in instructional approach are three of the factors that seem to impede the integration of technology into instruction (Edyburn, 2005a; Virga, 2007). Other factors include curriculum, administrative support, infrastructure, and availability of technology resources within the RSP classroom (Cook, Tankersley, & Landrum, 2009; Dyal, Carpenter, & Wright, 2009; Newton & Dell, 2009).

In order to make the transfer of technology knowledge to instructional practice, RSP teachers must learn how to integrate and manage the technology tools with which they are already familiar. Because RSP teachers work in isolation, a community of practice (CoP) can be used to provide ongoing support in implementing technology within instructional practice (Courduff, 2011; Edyburn, 2008; Wenger, 1998).

Communities of Practice

A community of practice (CoP) refers to any group of people who are involved in a mutual activity, shared goal, or creation of collaborative vision (Lave & Wenger, 1991). Wenger (1998) lists three distinct features of CoPs: (a) engagement, where individuals collaborate in an evolutionary process of defining and refining identities, (b) imagination, where individuals are involved in creative cognitive processes to learn and redefine the community according to their culture, and (c) alignment, where individuals are committed to the maintenance of their cultural norms, stories, and the invention and redefinition of these stories. Communities of practice assume that sharing ideas, best practices, and resources through storytelling and informal dialog takes place naturally (Bronack, Riedl, & Tashner, 2006; Glazer & Hannafin, 2008; Li & Guy, 2006). These communities are interactive and vary in their level of organization, and they are natural learning environments in which an apprenticeship model is carried out. The communities have the potential to be safe places where teachers can begin to understand and integrate technology resources (Sheehy, 2008).

Providing one-day or weeklong technology professional development training is not enough to support sustained integration (Courduff, 2011). Teachers need ongoing opportunities for technology skill support, time to share successes and failures, and space for sharing ideas in order to deeply understand the process of authentic technology integration. Communities of practice provide this necessary arena of support. A technology integrated CoP should use a pre-existing CoP because the teachers already feel comfortable within the group. The existing CoP can be retooled, using online technology resources for collaboration. However, simply changing the mode of collaboration and communication to an online format will not be enough to initiate and sustain technology integration change for teachers (Lawless & Pellegrino, 2007).

Teachers are resistant to change even when they are aware of the value of the technology innovation being introduced (Virga, 2007). Change is difficult and time-consuming, and research has demonstrated that people are often resistant to it, even when it is beneficial (Anderson, 2008; Christensen, 2008; Kotter, 1996; Kowch, 2009). It is therefore critical that teachers be provided with opportunities to discuss concerns and fears about technology integration so that it can be successfully implemented in the classroom (Potter & Rockinson-Szapkiw, 2012). It is also crucial that, through the CoP, teachers are provided with long term support, have opportunities for higher-order thinking, and include targeted application of knowledge to embedded technology use in day-to-day practice (Lawless & Pellegrino, 2007). Research has also recommended that teachers be guided through using technology tools within instruction (Courduff, 2011; Desimone, 2009). Therefore, for this study, matrices were developed that align common learning tasks with technology tools to help RSP teachers make connections between tasks and tools within instruction (Courduff, 2011; Edyburn, 2005a). Through a two-part strategy, RSP teachers learned to use the matrices within a CoP that was highly personal, emotional, and a bit serendipitous. This proved to be an effective way to support RSP teachers' technology integration in the classroom.

Matching Tasks and Tools within an RSP Community of Practice

Initial training in the use of a technology tool is not enough to support sustained integration (Courduff, 2011). Rather, an effective professional development opportunity model should include 3 aspects: (1) technology operation, (2) technology application, and (3) technology integration with mentor and community support (Potter & Rockinson-Szapkiw, 2012). Teachers should be guided through four stages in using technology tools: (a) introduction to the technology tool, (b) instruction on how to use the tool, (c) instruction on how to integrate the tool into teaching and learning, and (d) instruction on how to manage the tool with students. Although the stages sound very simple, research suggests that training stops at the second stage—how to use the tool (Desimone, 2009). Based on the review of the literature, matrices were developed that use a set of widely applicable, generally acceptable technology resources to guide the development, delivery, and evaluation technology into the daily teaching and learning activities of RSP teachers. This proved useful in addressing the gap between technology knowledge and subsequent application within instruction. Tables 1 and 2 comprise the matrices that were used as a support for RSP teachers in connecting curricular tasks with technology tools.

Theoretical Framework

The study was based on the theoretical framework of social learning theory (Lave & Wenger, 1991), and systemic change theory through the lens of the concerns-based adoption model, or CBAM (Hall & Hord, 2001). These theorists produced a foundation of research on the process necessary to actualize sustained learning for adults. They supported the notion that transfer of learning to practice occurs over time and among people. Adults transfer knowledge to practice most successfully in situated environments where learning is applied to practice in context (Barab & Squire, 2004; Lave & Wenger, 1991). When the concerns and needs of participants are continuously and proactively addressed by mentors or coaches, sustainable change within

Table 1. *Matrix of Reading/Writing Tasks and Appropriate Technology Tools*
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Curriculum tasks	Design strategies	Hardware	Tools/software
Reading	Universal design for learning (ULD)– cognitive rescaling Universal access: Architecture vs. curriculum (CAST)	○ MS Office™ programs ○ AlphaSmarts™ ○ Fusion Writers™ ○ iPod/iPod touch™ ○ PDA/handhelds ○ Interactive whiteboard ○ Interactive dance mats (i.e., RM EasyTeach DanceMats™) ○ Student response systems ○ AAC devices	○ Text to speech (screen readers) ○ Word recognition ○ Hypertext ○ Animated graphics ○ Video ○ Supported digital texts ○ Digitized speech ○ Online tutorial programs (i.e., Study Island™, Rosetta Stone™) ○ ClickIt™ ○ Typing software ○ Intellitalk™ ○ Speech-to-text (i.e., WordQ™/SpeakQ™) ○ Graphic organizers (i.e., Inspiration™/ Kidspiration™) ○ Accessibility websites– www.bookshare.org, www.sheppardsoftware.com ○ Tutorial development (i.e., Jing™) ○ Start-to-finish books ○ iPod touch/iPad Apps
Writing	Mainstream design: ○ Visibility: User can determine options for advancing learning on a device intuitively ○ Conceptual model: Device offers consistency of operations and feedback ○ Mapping: User can determine relation-ships between actions/results; controls/effects; what is visible/what is available on the system	○ MS Office™ programs ○ AlphaSmarts™ ○ Fusion Writers™ ○ iPod/iPod touch ○ PDA/handhelds ○ Interactive whiteboard ○ RM EasyTeach DanceMats™ ○ Student response systems ○ Digital camera ○ Microphone	○ Scaffolding ○ Concept mapping/graphic organizers ○ Typing tutorials ○ Spell check/custom vocabulary/thesaurus ○ Voice recognition ○ Graphics/picture support ○ Word prediction/word counts ○ Auto summarize ○ Writing statistical analysis, Kincaid score, frequency lists ○ Co-Writer™ /Write OutLoud™ ○ Study Island™ ○ Typing software ○ Intellitalk™ ○ WordQ™/SpeakQ™ ○ iPod touch/iPad Apps ○ Accessibility websites– www.readwritethink.org

Table 2. *Matrix of Math/Social Science Tasks and Appropriate Technology Tools*

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Curriculum tasks	Design strategies	Hardware	Tools/software
Math	Mainstream design: o Visibility: User can determine options for advancing learning on a device intuitively o Conceptual model: Device offers consistency of operations and feedback o Mapping: User can determine relationships between actions/results; controls/effects; what is visible/what is available on the system o Feedback: User receives full continuous feedback	o MS Office™ programs o Fusion Writers™ o iPod/iPod touch™ o PDA/handhelds o Interactive whiteboard o RM EasyTeach DanceMats™ o Student response systems	o Spreadsheets/Databases o Graphing calculators o Gaming software o Tutorial software o Contextualized math word problems through web-based learning environments o Math websites o Study Island™ o iPod touch™/iPad™ Apps
Social Studies	Mainstream design: o Visibility: User can determine options for advancing learning on a device intuitively o Conceptual model: Device offers consistency of operations and feedback o Mapping: User can determine relationships between actions/results; controls/effects; what is visible/what is available on the system o Feedback: User receives full continuous feedback	o MS Office™ programs o iPod™/iPod™ touch o Interactive whiteboards o Digital camera o Microphone	o Supported digital texts o Presentation tools o Spreadsheets/databases o Virtual field trips o Virtual reality websites o Concept mapping/graphic organizers o Research tutorials o Screen readers o Text-to-speech o Interactive simulation games (Oregon Trail™) o Inspiration™/Kidspiration™ o iPod touch™/iPad™ Apps o social studies websites– www.besthistorysites.net, www.bensguide.gpo.org, www.pbs.org/history,
Science	o Three-dimensional learning environments o Experiential learning o Social skills	o High end computer system o Interaction in both simulated and real worlds o Digital camera o Microphone	o Virtual reality games o Screen readers o Text-to-speech o PDAs o iPod™ touch/iPad™ Apps o Websites– www.enabling.org/grassroots
Social Skills	o Three-dimensional learning environments o Experiential learning o Social skills	o MS Office™ o programs o Digital camera o Microphone	o Social stories o Multi-User Domain, Object Oriented (MOO)/Multi User Domain (MUD) o Social skills websites

instructional practice can occur (Hall & Hord, 1987; Hall & Loucks, 1977). Learning is then diffused among members of the community, as in a community of practice (CoP), through a series of continuous feedback loops of training, support, follow-up, and troubleshooting (Desimone, 2009; Glazer & Hannafin, 2008; Hall, Loucks, Rutherford, & Newlove, 1975; Lave & Wenger, 1991).

Purpose Statement

The purpose of the study was to explore participants' experiences in learning to use matrices (Tables 1 and 2) through a community of practice (CoP) to bridge the gap between technology knowledge and instructional practice. The research addressed the following questions:

RQ1–Value: Did using the matrices within a CoP affect perceived value in using technology tools to enhance instruction?

RQ2–Frequency: Did using the matrices within a CoP affect how frequently participants match technology tools with curriculum tasks?

RQ3–Transfer gap: Did using the matrices within a CoP bridge the gap from technology knowledge to application of knowledge to instructional practice?

Research Design

The nature of teaching in the RSP environment is complex. Thus, a design-based research approach was adopted as it aims to examine the complexity of real-world practice. Context is the key to understanding the underlying nuances of the instructional environment and challenges within (Barab & Squire, 2004). A two-part strategy was used to explore how RSP teachers transferred knowledge to instructional practice within the context of special education instruction. The first part of the strategy involved using the matrices as an intervention tool. The matrices were introduced to participating RSP teachers as a resource for integrating technology into instruction. The matrices enabled participants to make connections between available technology tools and student learning tasks with the result that technology was integrated more frequently. The second part of the strategy involved participation in a CoP while learning to use the matrices as a resource for technology integration. Participation in the CoP provided situated, ongoing support that was not possible through off-site formal training (Li & Guy, 2006; Lu & Overbaugh, 2009).

Through group interaction and discussion, participants could find shared value in using technology tools to address student curriculum and IEP growth goals. Using the two-part strategy allowed the study of participants' experiences using the matrices as an intervention tool while collaborating through the CoP. This aligned with design-based research methods because the study extended beyond merely designing a matrix and testing it as an intervention. Rather, "interventions embody specific theoretical claims about teaching and learning, and reflect a commitment to understanding the relationships among theory, designed artifacts, and practice" (The Design-Based Research Collective, 2003, p. 1).

A conjecture map was used as a tool to systematically focus on the situated learning experiences and concerns of the participants from individual and group perspectives. The map connected the theoretical framework to (a) research questions, (b) data needs, (c) data collection, (d) data analysis, and (e) implication of findings to learning theory (Sandoval & Bell, 2004; The Design-Based Research Collective, 2003). Data were collected throughout the study and included survey responses, recorded focus group meetings, preliminary interviews, and semi-

structured interviews. Table 3 provides a graphic organizer of the research process as actualized in a conjecture map.

Table 3. *Research Process Conjecture Map*

Theoretical conjectures based on theoretical framework →	Embodied conjectures: research →	Embodied conjectures: data needs →	Intermediate outcomes: data sources →	Objective outcomes: data analysis
1. Situated/social learning within a CoP where value perceptions are created, fostered, or changed.	1. How will the use of the matrices within a CoP affect participants' perceived value in using technology to enhance instructional practice?	1. Participant experiences and change in behavior and attitude using the matrices during participation in CoP.	1. Focus group meetings, semi-structured interviews, electronic communication within the CoP.	1. Change in attitude: perceived value for instruction potentially increasing student achievement.
2. Systemic change (i.e., CBAM) addresses change at the personal level where individual levels of use and stages of concern can be discovered and addressed. This increases the likelihood of increased frequency of technology integration.	2. To what extent will using the matrices within the CoP affect how frequently participants match technology tools with curriculum tasks?	2. Initial participant knowledge and skill levels, growth in application of knowledge to practice.	2. Secondary analysis of initial and follow-up EdTech profile surveys.	2. Change in behavior: frequency of technology integration.
3. This study extends diffusion of information to the gap found in the transfer of knowledge to situated instructional practice.	3. How does using the two-part strategy extend the learning process of RSP teachers from knowledge to synthesis within instruction?	3. Participant knowledge transfer experience as coded through initial categories and emerging themes.	3. Revision of approach within CoP and focus group meetings based on participant–researcher interactions.	3. Change in practice: Implications on how knowledge is transferred to practice in challenging environments.

Participants and Setting

A convenience sample of 17 RSP teachers employed by an elementary school district in the southwestern United States were invited to voluntarily participate in the study. Of the 17 invited, 10 agreed to participate. The sample consisted of females ($N = 10$; 100%) from various ethnicities, including African American ($n = 2$, 20%), Hispanic ($n = 2$, 20%), and Caucasian ($n = 6$, 60%). Participants ranged in age from 25 to 56 years. All participants ($N = 10$, 100%) held both Bachelor's and Master's degrees.

The RSP teachers participated in formal training sessions through the Professional Development Center in the school district. Formal training and subsequent activities used CBAM strategies to monitor teachers' concerns and measure progress (Hall & Hord, 2001). The formal training was also extended through voluntary participation in a face-to-face and online CoP where teachers attended short training sessions, practiced skills, shared ideas, and helped each other with technology issues.

Although no financial compensation was available for study participants, each participant was provided with a technology tool kit. The kits were purchased by the district using federal grant funds and low incidence money. Each kit included a low-tech assistive technology (AT) resource binder, headset microphones, children's talking dictionary, talking calculators, Fusion writers, a variety of grade-level-appropriate interactive software, a list of universal design for learning and other intervention website resources, and the matrices provided in Tables 1 and 2. Participants had access to iPod touches with cases, screen protectors, and convertible netbooks with touch screens if these tools were required on a student's IEP.

Data Collection

Data were collected from the participants using qualitative and quantitative methods. Qualitative data included recorded focus group meetings, preliminary interviews, and semi-structured interviews. Tables 4 and 5 list thesample questions provided for interviews and focus groups. These tables also aligned interview questions with research questions, theoretical categories, initial themes, and data sources. The questions provided in the tables were used in an order suited to the unique flow of interaction during individual interviews and focus group meetings.

Quantitative survey data were collected using a state-adopted Technology Assessment Profile Survey (2010). The survey was used to measure participants' technology knowledge levels and frequency of technology integration within instructional practice. The survey included closed-ended questions relating to teachers' levels of technology knowledge and integration in the following categories: (a) general computer knowledge and skills, including Internet and email skills, (b) word processing skills, (c) presentation software skills, (d) spreadsheet software skills, and (e) database software skills. For each subcategory, participants self-reported, using a Likert scale from zero (no use) to five (advanced user).

Results

Data were analyzed using an interpretive exploratory strategy (Creswell, 2003). The focus of data analysis was to explore participants' experiences in using the matrices within a CoP, and how these experiences could bridge the gap from knowledge to technology-embedded instructional practice. Data were collected and analyzed for impact on perceived value (RQ1), frequency of technology integration (RQ2), and progress toward bridging the gap from technology knowledge to application of knowledge within instructional practice (RQ3). Data analysis of survey results provided initial findings addressing value (RQ1), and frequency (RQ2). Figure 1 provides a snapshot of group average growth by category comparing averages of initial and follow-up surveys.

Table 4. *Preliminary Interview Questions*

Research questions (RQ)	Question	Data source
RQ3–Transfer	Tell me about your colleagues–how do you organize communication between classroom and IEP goals?	Preliminary interview, focus group
RQ1, RQ3–Value, transfer	What technology tools are you currently using?	Preliminary interview, focus group
RQ1–Value	Are you using technology tools daily, weekly, or monthly?	Preliminary interview
RQ2–Frequency	How are you using technology for learning tasks?	Preliminary interview, focus group
RQ1, RQ2, RQ3–Value, frequency, transfer	How has that been working? What is working/not working?	Preliminary interview, focus group
RQ2–Frequency	What technology interventions have you tried/are you trying?	Preliminary interview, focus group

Table 5. *Sample Interview and Focus Group Questions*

Research questions (RQ)	Question	Data source
RQ2–Frequency	How are things going in your classroom?	Semi-structured interview
RQ1–Value	What changes have you made in using technology in instruction in the last few weeks?	Semi-structured interview, focus group
RQ1, RQ3–Value, transfer	How do you feel, or do you feel, that the matrices have been useful to selecting technology tools?	Semi-structured interview, focus group
RQ2–Frequency	What would help you use the matrices more often?	Semi-structured interview, focus group
RQ1, RQ2, RQ3–Value, frequency, transfer	Is there anything else you would like to add?	Semi-structured interview, focus group

An additional comparison of initial and follow-up survey results from an individual participant perspective revealed that 8 of the 10 participants increased in overall proficiency. Participant 8 had the greatest growth average, moving from an overall proficiency of 1.7 (beginning range) to 2.4 (intermediate range). Participant 1 moved from 2.9 (intermediate range) to 3.0 (advanced range). Two participants' overall proficiency levels dropped. Participant 3 had a decrease in average proficiency from 2.6 to 2.0 but remained in the intermediate level. Participant 9 had a decrease in average proficiency from 2.7 to 2.3,

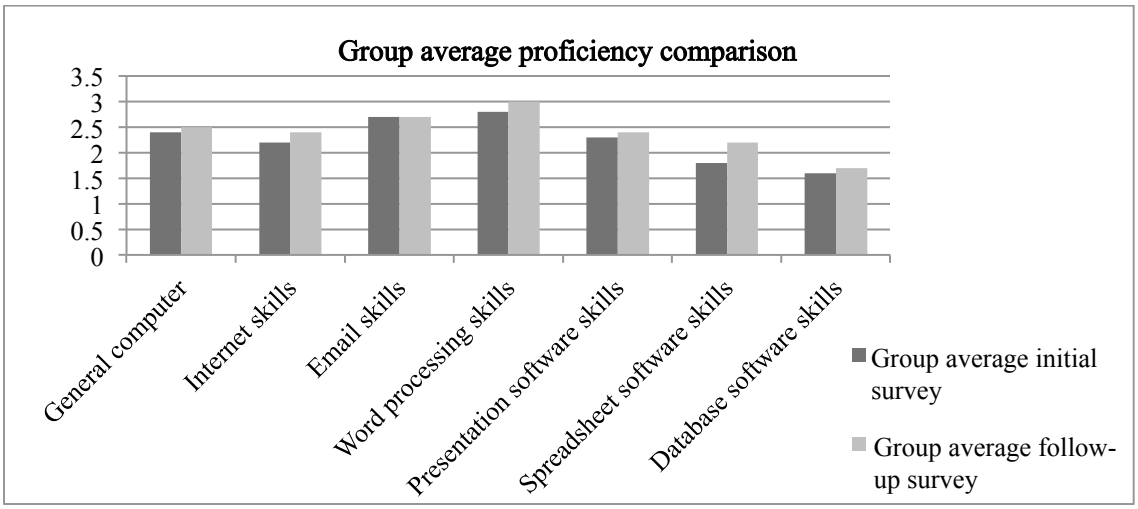

Figure 1. Survey proficiency average growth.

but also remained in the intermediate level. When asked about this drop, the participants indicated that the scores dropped because they became more aware of their actual knowledge levels during the study. They felt they had misjudged their level of technology proficiency on the initial survey, and consequently self-reported lower levels of proficiency on the follow-up survey. Survey results were reviewed with each participant in the course of member checking for accuracy in data collection, analysis, and interpretation. All participants confirmed that the results were accurate.

The triangulation of interview, focus group, and survey data specifically addressed the third research question, which focused on the transfer of technology knowledge to synthesis within instruction. Simply put, *transfer* refers to moving along a continuum from knowing about technology tools to knowing how to integrate those tools into instruction meaningfully and appropriately (Desimone, 2009). All data were cross-coded for emerging factors indicating which participants were able to transfer technology knowledge to instructional practice (Creswell, 2003). The data were subsequently triangulated for emerging factors that enabled or impeded the transfer of knowledge to practice for the participants.

All participants started by learning to use the matrices within the CoP. The combination of the matrices and the supportive situated learning environment of the CoP caused an increase in the value that all participants placed on technology for instruction. Among the 10 participants, 9 used the tools more frequently; 7 participants were able to apply knowledge resulting in change within instructional practice through factors that enabled transfer, whereas 3 participants were unable to transfer knowledge to instructional practice through factors that impeded transfer.

Factors that enabled transfer included (a) awareness of tools available in the classroom, (b) novelty of new technology tools such as apps and website resources, (c) empowerment to shift the mindset from using traditional resources to using technology-embedded activities, (d) increased student engagement and learning, (e) group interaction and sharing through the CoP, (f) the matrices as a resource repository, and (g) continued participation in the CoP for summer planning.

Factors that impeded transfer included (a) frustration with technology tools that failed to work properly, (b) lack of adequate planning time, (c) isolation brought on by working at

different sites, (d) instructional control issues with general education teachers, (e) year-end IEP and placement meetings, and (f) the mindset, embedded in the teaching culture, that traditional resources are superior to technology-embedded activities.

Table 6. *Factors Enabling/Impeding Transfer*

Factors that enabled transfer (i.e., supports)	Percentage of participants for whom this theme was salient	Factors that impeded transfer (i.e., barriers)	Percentage of participants for whom this theme was salient
Awareness	100%	Tool failure	50%
Novelty in new technology tools	80%	Lack of adequate instructional time	70%
Using technology resources instead of worksheets (shift)	90%	Isolation	70%
Student engagement	80%	Year-end meetings	80%
Group interaction and sharing	90%	Mindset shift in embedded in teaching culture: using traditional resources vs. using technology	60%
Matrix to raise resource accessibility	100%	Control	30%
Extend group meetings in summer	90%		

Factors Enabling Transfer. Factors that supported the transfer of knowledge to synthesis within instructional practice included awareness, novelty, resource repository, mindset shift, student engagement, group interaction and sharing, summer planning, and instructional control.

Awareness. Using the matrices through the CoP raised participants' awareness of the technology resources that were available in their instructional environments. Participant 7 stated that the matrices raised awareness in the moment: "I find that I forget about using things in the moment. The matrices keep me aware of the tools that I do have" (focus group session two, April 25, 2011).

Novelty. Novelty emerged as a supportive factor because new ideas and resources motivated participants to integrate technology into instruction and learning more frequently. Participant 10 stated that the matrices reenergized her instruction:

> I am very excited about all the new websites I can go to that provide practice for my RSP students on a specific skill while I pull others into smaller groups to focus on their needs. I don't know about you, but I needed something like this to help me provide more interesting

and individualized instruction. This will also be helpful those days when one of the RSP staff members is absent and the others are left to carry the load (semi-structured interview, May 3, 2011).

Resource repository. The matrices functioned as a resource repository where participants could select technology tools that were appropriate for different curriculum tasks. Participant 9 described it as having a one-stop shop. Participant 2 stated that using the matrices caused her to think about technology integration in a more targeted way. As the study progressed, participants shared newly discovered website resources through the CoP. Participant 4 stated, "I actually started typing a list of those [new websites] and I will send it to you so you can add it to the matrices. The matrices and this whole study has made me more aware of using technology in class" (focus group session two, April 25, 2011). At the end of the study, all participants requested updated matrices for use in summer planning. Participant 5 asked, "At the end of all this, will we get an updated matrix? That would be such a great resource to have to look at over the summer and use for planning" (semi-structured interview, April 30, 2011).

Mindset shift. The transfer of knowledge to instructional practice led to an emergent code that the researchers termed *mindset shift* throughout the data coding process. *Mindset shift* refers to the participant's ability to transition away from using traditional learning resources such as worksheets to using technology-embedded activities. Participants began to use the matrices intentionally to select technology tools as a different way to approach the curriculum task at hand. For example, in the final interview, Participant 5 stated, "I feel a little more empowered and equipped to use technology over worksheets" (semi-structured interview, April 30, 2011). This response was typical among the group of seven who were able to make the transfer. Participant 5 discovered that the *mindset shift* to using technology over traditional learning activities made a positive impact on student behavior. One of her students was very frustrated with a writing assignment. Participant 5 decided to try the word prediction program on a portable writing device instead of making the student complete the assignment with pencil and paper. The student's level of frustration decreased significantly. "I went from a boy who was standing with his head against the door saying, 'I don't want to talk to you,' to one who was sitting and doing an assignment" (semi-structured interview, April 30, 2011).

Student engagement. Increased use of technology resulted in improved student engagement and behavior. Participant 10 stated, "I found that my 5th graders who were real behavior issues were much better using that [the interactive white board]. A lot of my problem is extinguishing behavior so we can get to instruction" (semi-structured interview, May 3, 2011). Participant 4 expressed that she "liked having the kids type, working on their paragraph formation. Sometimes they get tired of the paper/pencil and I say, 'okay, go to the computer.' They are focusing on word processing and their writing all at once" (semi-structured interview, April 25, 2011).

Group interaction and sharing. Group interaction and sharing through the CoP motivated participants to try new technology resources. Participants were able to share how they were using the matrices to integrate technology into instruction. "Before [the study] I thought, 'Wow, I don't know what to do with the computer, I don't know what to do with the kids, and so I didn't touch it. Now I'm willing to try it" (Participant 10, semi-structured interview, May 3, 2011). Group interaction also created a shared sense of community. "As a group, we are a good resource for each other" (Participant 9, semi-structured interview, May 1, 2011).

Extension of CoP: Summer planning. At the end of the study, all participants expressed a desire to continue meeting within the CoP. Many partcipants expressed frustration in not using the matrices as much as they had hoped to during the study. Participant 9 stated, "I would like to be part of the group as it continues. I have found so many things in the matrices that I wanted to do but don't have the time to experiment" (semi-structured interview, May 1, 2011). Participant 8 was enthusiastic about continuing the CoP. "I'm glad we are going to continue the group in the summer. It will give me more time to play with things and explore" (semi-structured interview, May 5, 2011).

Control. Instructional control emerged as a factor that either enabled or impeded the transfer of technology knowledge to instruction, depending on each participant's working relationship with general education teachers at various school sites. Certain participants worked at sites with high levels of collaboration amoung special and general education teachers. Others indicated that there were issues of instructional control and that, often, the general education teachers made the instructional decisions regarding the selection of student learning activities.

On one end of the spectrum, Participant 2 had no trouble with the worksheet issue. "I pretty much have the teachers trained. Every once in awhile I get work [handouts] from a teacher and I laugh, write 'excused' across the top, and send it back" (preliminary interview, March 23, 2011). Participant 9 was looking forward to sharing the matrices with her general education colleagues. "I want to bring technology to the general education teachers and show them what I'm learning" (semi-structured interview, May 5, 2011).

On the other end of the spectrum, in the first focus group session, participants were asked whether technology integration was impeded by general education colleagues, and if so, why. Participant 7 explained the issue from her perspective.

> I'll tell you why. I have a great relationship with the teachers that I work with but their focus is curriculum based. If I showed them the Flashmaster [math tutoring device], they would not want me to use it because they have worksheets that they need turned in by the students. I even have an iPod [touch], and I don't have time to use it because they have worksheets they want me to complete with the students. I don't have time to use technology because of all of the things the teachers need from me. They're nice people and I don't want to say anything against them." (focus group session one, April 8, 2011)

Instructional control functioned as a factor that both enabled and impeded transfer in data coding and analysis.

Factors Impeding Transfer. One participant articulated the challenge in this manner:

> The biggest challenge to special education is that it is always changing. Procedures and policies change from month to month, year to year. This lack of consistency creates an environment where everything is an add-on. To change the mindset that technology is not an add-on will be tough to break. Our whole job functions around the words, 'it depends.' (semi-structured interview, May 5, 2011)

Factors that impeded transfer included isolation, tool failure, lack of time, and year-end meetings.

Isolation. Seven of the participants were the only RSP teachers at their school sites. This created a sense of isolation, which decreased the possibility for collaboration on technology

integration. Participant 5 stated, "The study made me realize I'm not alone. We are all in the same boat out there in this big ocean. Everyone struggles in the same area" (semi-structured interview, April 30, 2011). Through participation in the CoP, isolation was reduced for all participants. Participant 7 stated that being part of the group helped diminsh the sense of isolation: "I learned how other teachers deal with general education teachers through the group interaction" (semi-structured interview, May 3, 2011).

Tool failure. The failure of hardware, software, and website resources emerged as an impediment to integration in the data coding. One resource that caused frustration was the district-approved language arts textbook website, http://www.eduplace.com/kids/hmr05/. Participant 7 stated that many of the links did not work. This was frustrating to her students who were just learning to navigate the Internet. Participants indicated great frustration over trying to use different speech-to-text software programs. As participants attempted to use various speech-to-text programs, many found that none of the programs worked well with student voices. One reason for this might be that student voices tend to have a higher pitch and are not as easily understood by speech-to-text programs. While most speech-to-text programs continue to improve from year to year, most programs were not robust at the time of the study. Tool failure wasted instructional and planning time.

Year-end meetings. The study took place in the final trimester of the school year. Data revealed that participants were required to attend many IEP and transitional meetings during the timeframe of the study. Participant 2 noted her frustration at missing focus group meetings because of year-end meetings. "I am frustrated I wasn't able to contribute to the group more, but I have been in IEP meetings, and with state testing it's even worse" (semi-structured interview, May 5, 2011). Year-end meetings functioned to decrease the amount of time participants spent communicating within the CoP and also the amount of instructional time participants were spending with students.

Lack of instructional time. Participants serviced students in small group rotations of approximately 30 to 45 minutes. Participant 3 explained the difficulty of technology integration during such a short timeframe: "You see the kids for a very, very brief amount of time. The kids work even at a slower rate. To try and get everything done that you know that they need and try to fit in any fluff stuff is almost next to impossible" (semi-structured interview, May 9, 2011). Additionally, some participants expressed a time barrier imposed by the district. The district required that teachers adhere to a predetermined Math pacing guide. Participant 6 stated that the pacing guide requirement limited time that could have been spent on a technology-embedded activity. "We have to stay up with the district pacing guide which leaves no time for technology" (semi-structured interview, April 7, 2011).

Discussion

As participants learned to use the matrices within the situated learning environment of a CoP, they began to understand the value of technology for instruction and student learning. Thus, most participants used technology more frequently for instruction. Ongoing collaboration in the CoP sparked discussion and the sharing of ideas for seven participants who consequently began to

replace traditional learning activities with technology-embedded activities. These seven participants were able to make positive changes in practice as revealed in data findings.

These findings reaffirm and enrich the theoretical basis for this study. The transfer of technology knowledge to practice most successfully occurs in situated environments where learning is applied to contextualized instruction and participant concerns are addressed (Barab & Squire, 2004; Hall & Hord, 2001; Lave & Wenger, 1991). The combination of using matrices within a CoP supported the transfer of knowledge to instructional practice. Consequently, this strategy can contribute to change in the way pre-service coursework and professional development is designed and implemented by universities and school districts.

Traditional professional development and pre-service teacher coursework fall short of meeting the needs of teachers in complex instructional environments, including special education. First, the matrices provide a resource for in-the-moment technology integration. The matrices enable teachers to embed technology into instruction and learning activities by helping them make immediate connections between the curriculum tasks and technology tools—resulting in real integration during instruction.

Added interaction through participation in the CoP provided help and support in learning how to use and manage technology resources with students. Seven participants began actively and purposefully planning technology for instruction because they were supported in learning to manage the tools through participation in the CoP. In order to make the final transfer of knowledge to instructional practice, special education teachers need support in learning how to integrate and manage the technology tools they already know how to use. Consequently, pre-service teacher coursework and in-service professional development should place more attention on the integration and management of technology resources into instructional practices of all teachers. This can be actualized when a two-part strategy is used to move teachers along the continuum from technology knowledge to instructional synthesis. The alignment of curricular tasks with technology tools through set of matrices within a supportive CoP can help teachers learn to select and integrate technology resources more creatively in addressing student learning needs.

Limitations and Recommendations for Future Research

The findings of this study can be generalized to other populations of teachers who face challenges of complex instructional environments. While the findings have important implications for the complex instructional environments of RSP teachers, they can be generalized to other instructional environments within special education, such as special day class and speech-language pathologist instruction.

Increased awareness can lead to action in changing pre-service teacher coursework and professional development that supports technology integration instructional needs of RSP teachers and special education teachers who face similar instructional challenges. University and school district program leaders should consider changing the approach to technology integration within special education to include strategies that are practical and adaptable for all special education teachers. Future research is needed on the impact of using matrices within a CoP on deepening the level of technology integration with teachers in complex instructional environments. Longitudinal research is needed to determine whether the transfer of knowledge to synthesis within instructional practice affects achievement levels of students with special needs.

Conclusions

Technology integration within RSP instructional environment is complex. Teachers must address curriculum, IEP goals, and the broad range of learning deficits found in students with special needs. This complexity results in a challenge for the integration of technology into instructional practice. Study findings revealed that when teachers learn to connect curriculum tasks to technology tools in a situated, supportive environment, the possibility of technology integration is increased. However, successful transfer of technology knowledge to instructional practice cannot be assumed. Rather, true synthesis of technology-embedded instruction requires practice over time in situated environments where individual concerns are addressed within a supportive CoP (Hall & Hord, 2001; Wenger, 1998).

Honesty and trust must be part of the group interaction. Change in the levels of deep technology integration can occur when teachers are guided in making connections towards technology-embedded student activities through communication, support, and the underlying belief that technology is a powerful tool for engaging and motivating students to learn.

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Collaborative Academic-Government Agile Development of a Cloud Prototype Fire Retardant Drop Log Application for Wildfire Management

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Abstract
Two billion dollars are spent annually in the U.S. combatting wildfires. USAF Aircraft are converted into Modular Airborne Fire Fighting System air tankers. Law requires the U.S. Forest Service to track expenses related to firefighting and reimburse the Defense Department. The current process requires flight crews to record information on a manual Drop Log form. A computerized system was developed using Agile concepts in both pedagogy and systems development. State-of-the-art cloud infrastructures were used to implement a free, proof-of-concept digital Drop-Log on Azure Cloud using a MySQL database. Innovative, Agile pedagogical and development processes produced a working prototype in two months.

Key Words
Agile, cloud computing, collaboratory, MAFFS, relational database, virtualization, wildfire management

Introduction

Each year, nearly two billion dollars are spent combatting wildfires in the U.S. (Suppression, 2014). During summer months, fire activity increases to a point where it is in the national interest to call upon the National Guard and Reserve to conduct aerial firefighting operations using Department of Defense aircraft. This mission set relies on USAF C-130 aircraft crewed by members of the Air National Guard and Air Force Reserve.

The Modular Airborne Fire Fighting System, or MAFFS, converts USAF C-130 aircraft into very capable firefighting air tankers. The MAFFS mission is executed in support of the U.S. Forest Service, part of the Department of Agriculture. These MAFFS aircraft dispense up to 3,000 gallons of fire retardant in 5 seconds on vegetation source fuels ahead of a wildfire (California Department of Forestry and Fire Protection, n.d.); see Figure 1.

Expenses related to the conduct of MAFFS aerial firefighting operations previously have been captured manually using a form known as the "MAFFS Drop Log." The Drop Log is the sole source of information used by U.S. federal and state government agencies to determine funding budgets to fight escalating numbers of annual wildfires. The MAFFS mission is executed in support of the U.S. Forest Service, part of the Department of Agriculture. Under provisions of law (U.S. Economy Act, 2014, 31 U.S.C. §1535), the Department of Agriculture must reimburse the Department of Defense for its support of this vital mission.

This paper describes the implementation of a MAFFS Drop Log database management system (DBMS) used to replace the manual process of logging, referred to as the LSystem. The LSystem is a master's degree project in the Computer Science program of the School of Engineering and Computing (SOEC) of National University (NU). In this project, the MAFFS Drop Log is converted to digital format, providing rapid access to firefighting activity and processes.

Figure 1. MAFFS drop of retardant. Photo by Senior Airman Nicholas Carzis, U.S. Air Force; reprinted with permission.

The LSystem is a collaborative research initiative that uses leading-edge, innovative teaching and technological techniques: a collaboratory, Agile project development and state-of-the-art cloud technologies. This project, completed in two months, is an example of not only research but beneficial implementation of innovative pedagogy and experiential learning to create a useful product.

Collaboratory

A collaboratory is defined as being "virtual" and promoting "working together apart" (Kouzes, Myers, & Wulf, 1996), which has been perceived to significantly increase the output and productivity of researchers. Collaboration is at the heart of science. NU finds satisfaction in being involved in community service and supporting advanced education of U.S. military personnel. This paper reports a collaborative research effort between (a) NU and its community service support of wildfire management, (b) the SOEC Master of Science in Computer Science (MSCS) program, (c) a graduate student with vision (author Allen), who is a recognized national subject-matter-expert on MAFFS, (d) Colonel Brian Kelly, vice Wing Commander of the 146th Airlift Wing, Channel Islands Air National Guard in California, the sponsor of this project, and (e) Miles Romney of Spork Labs, who continues to collaborate with NU by providing the latest Ruby on Rails development tools. Beneficiaries of this research are residents not only in Southern California but throughout all of California and other western states.

Agile Project Development

LSystem was developed using the agile development process. According to the *Manifesto for Agile Software Development* (2014), *Agile* defines a culture that values individuals and interactions over processes and tools.

The highest priority of agile is customer satisfaction through early and continuous delivery of valuable software. The process welcomes change, harnessing change for competitive advantage.

It focuses on delivering working software frequently, through daily interaction between the customer and developer throughout the project. Agile entrusts project development to trusted, talented, motivated individuals, supported by the tools and environment they need to excel. People, communications, product delivery, and flexibility are important agile concepts.

Although originally created for software development, agile principles have been applied to any process—software development, project management, and teaching. Management of the national MAFFS program is an example of agile concepts in management.

State-of-the-Art Cloud Technologies

The use of virtualization technology is particularly useful in the teaching of computer science and information technology curricula. This is an example of agile teaching, dynamically adjusted to meet the needs of the students and course material. In a rapidly evolving technological space such as that developing with cloud infrastructures, both instructors and students must utilize agile concepts, particularly in the NU course-per-month modality. Allen, in DAT604 Database Design and Implementation, and DAT605 Web and Cloud Computing used virtualization extensively on assignments. DAT605 introduced virtualization in the cloud that Allen used to create a proof-of-concept implementation of LSystem on Microsoft Azure, a cloud service provider (CSP).

In this paper, Allen illustrates the power of using multiple public CSPs—Azure, Bitnami, and Maestro—at minimal or no cost.

A Glossary of Information Technology and Other Terminology used in this paper is provided at the end of the paper.

Background

Ten Largest Wildfires in California History

The ten largest wildfires in California History (”Rim Fire,” 2013) are shown in Table 1.

Table 1. *Ten Largest Wildfires in California History*

Fire	Year	Location	Acres Burned	MAFFS Pilot
Cedar	2003 Oct	San Diego	273,246	Allen
Rush	2012 Aug	Lassen	271,911	Allen
Rim	2013 Aug	Tuolumne	257,135+	Allen
Zaca	2007 Jul	Santa Barbara	240,207	Allen
Matilija	1932 Sep	Ventura	220,000	
Witch	2007 Oct	San Diego	197,990	Allen
Klamath	2008 Jun	Siskiyou	192,038	Allen
Marble Cone	1977 Jul	Monterey	177,866	
Laguna	1970 Sep	San Diego	175,425	
Basin	2008 Jun	Monterey	162,818	Allen

Of these ten, seven were in an era where wildfire fighting was covered by national legislation that empowered the U.S. Military to use the Modular Airborne Fire Fighting System (MAFFS). Allen, one of the authors of this paper, served as a MAFFS pilot in fighting these seven fires.

Wildfire Disasters in California and Western United States

For many National University faculty, the wildfires of 2007 remain in vivid memory. The largest fire in California history remains the Cedar fire of 2003, as Table 1 shows. The combination of the Witch fire in October 2007 and the Harris fire, which does not appear in the top ten, however, would place these San Diego combined fires at the top of the list. Two NU faculty members, husband and wife, lost two homes in the same circle to the Witch fire. A satellite image of southern California, shown in Figure 2, reveals the active fire zones and smoke plumes in October 2007 ("October 2007 California Wildfires," n.d.). The October wildfires in California totaled about 30, with 17 of them being major fires. Over 1,500 homes were destroyed, and approximately 970,977 acres (1,500 square miles) were burned from Santa Barbara to the Mexican border. Fourteen people died in these fires. Some 1,000,000 people had to evacuate their homes in the largest evacuation in California's history. The Witch fire displaced more people than were displaced by Hurricane Katrina in 2005.

Figure 2. NASA Satellite photo, October 24, 2007

Annual suppression cost of wildfires has exceeded $1 billion in each year since 2000, according to the senior climate economist with the Union of Concerned Scientists. The average number of big western fires has risen from 140 per year in the 1980s to 250 in the 2000s (Rice, 2014). According to many civil firefighting agencies, the Modular Airborne Fire Fighting System is desperately needed for combating wildfire disasters.

Modular Airborne Fire Fighting System (MAFFS)

During daily operations of a MAFFS aircraft, information regarding each mission is manually logged on a form called a Drop Log. The Drop Log is used as a source document, providing the location and quantity of fire retardant that was dispensed during each flight sortie. This information is used to validate U.S. Forest Service expenses related to fighting fire and for

statistical purposes to provide feedback on the effectiveness and efficiency of the aerial firefighting program. One of the authors (Allen), by Air Force assignment, was one of the primary contributors in the specification of the Drop Log, in use for the past decade, and thoroughly understands the function of each data element and the Drop Log process.

Purpose of the MAFFS Drop Log Application

The MAFFS Drop Log Application System (LSystem), the subject of this paper, was developed as a master's graduate project in the MSCS program. It was created in response to a need perceived by Allen, an Air National Guard pilot, assigned to the MAFFS wildfire firefighting program. Although Department of Defense (DoD) and Department of Agriculture (DoA) constraints on automated systems make operationally deploying such an application administratively difficult, the LSystem demonstrates the usefulness of such an application and validates the need for more formal, DoD-driven, application development.

The objective of this research project is to implement a digital capture of MAFFS Drop Log data using or providing the following:

1. Agile system development concepts directed by standards
2. Cloud infrastructure resources (IaaS)
3. Cloud development resources (SaaS)
4. Cloud operational resources (PaaS)
5. A relational database management system (RDBMS)
6. A normalized relational database
7. A portable system
8. Client-server architecture that supports multiple users
9. Standard browser interface (iPad capable)
10. Dynamic update of MAFFS Drop Log information
11. Cost-free development computer resources
12. Demonstration of innovative pedagogical and developmental research tools

Users

Three distinct types of users will employ the automated LSystem: Aircrew, Military Command and Control (C2) Staff, and Forest Staff. Aircrew includes the Aircraft Commander or his/her designee. C2 Staff are the primary users of the LSystem; their responsibility will be to take the manually logged form and input it into the LSystem. Forest Staff may use the LSystem to derive specific information, including total flight hours flown, quantity of retardant dropped, and which fire incidents received retardant.

Functions

During the daily operations of a MAFFS aircraft, information regarding the mission is logged on a form called a Drop Log. The Drop Log is used as a source document that provides the location and quantity of fire retardant that was dispensed. This information assists U.S. Forest Service validation of expenses related to fighting wildfires in the U.S.

The Drop Log is maintained by the Co-Pilot or Navigator on board the C-130. It is updated throughout the day with information that includes the specifics of the aircraft used, the name of the aircraft commander, where and how much retardant was loaded, where it was dispensed, and

in how many increments it was dropped. This information is also used for statistical purposes, providing feedback on the effectiveness and efficiency of the aerial firefighting program.

Application Delivery

The fully functional proof-of-concept application is accessible through hypertext Internet protocol via industry-standard web-browser clients. An unlimited number of clients run custom server-side interpreted PHP code, provided by an Apache web server integrated with a MySQL database server backend (Apache, 2014; Oracle Corporation, n.d.). The entire server-side system, encapsulated in the Bitnami Tracks Stack, resides in the cloud, hosted on a virtual instance of Microsoft Server running on the Azure cloud service provided by Microsoft (Bitnami, 2014; Microsoft, 2014).

Useful Tools for Agile Development

Student success in the NU one-course-per-month modality is enhanced by agile use of technology (Dey et al., 2009; Katz, 2011; Romney, 2009; Sahli & Romney, 2010). Specific tools that have proved extremely productive are virtualization, Ruby on Rails framework, and cloud infrastructure.

Virtualization

The National Institute of Standards and Technology defines virtualization as the simulation of software and/or hardware solutions (Scarfone, Souppaya, & Hoffman, 2011). The individual environment is called a virtual machine (VM), and VMs facilitate operational efficiency, testing environments, better organizational control and security, and portable encapsulation. Another benefit of virtual environments, however, is to provide students with a tool that makes agile development possible, as one does not have to physically have a multitude of different computers. A quality feature of VMs is that they have the same components as physical machines. They have CPUs, memory, storage, and network controllers, and they require input devices such as keyboards and mouse devices. This makes them a perfect substitute for physical computers.

Virtualization facilitated student publishing in the one-course-per-month modality for graduate students Sahli and Anderson at NU (Sahli & Romney, 2010; Anderson & Romney, 2013; and Anderson & Romney, 2014). At NU, Virtualization of computing systems has successfully employed hypervisors such as VirtualBox, Parallels, VMware, and HyperV (Romney, Dey, Amin, & Sinha, 2013). Virtualization is part of the fundamental technology that has made cloud infrastructures possible and facilitated the rapid adoption of cloud concepts.

Ruby on Rails Framework

Two of the authors, G. W. Romney and M. D. Romney, have worked with the Ruby on Rails (RoR) framework for over 10 years, ever since it was initiated. The history of its successful usage in teaching is reviewed in a journal article (G. W. Romney, M. D. Romney, Sinha, Dey, & Amin, 2014). RoR software development is based on Agile principles (Manifesto, 2014; ”What Is Rails?” 2014).

Cloud Infrastructure

Virtualization and deployment of cloud infrastructures go hand in hand with the use of agile pedagogy (Anderson & Romney, 2013; Anderson & Romney, 2014; Romney, Amin, Dey, & Sinha, 2014). Allen, as a graduate student, made use of virtualization and cloud infrastructure in DAT605. This experience proved so agile and successful that Allen elected to extend it to the LSystem project in CSC686.

Students and faculty increasingly interact with databases (Big Data, n.d.; "Special Report," 2010; IBM, n.d.) through mobile computing, cloud computing, wireless networks, and distributed information repositories. Frequently this is referred to as mobile cloud computing, and it influences the very framework of education, at all levels, at an accelerating pace (Romney et al., 2014; Romney & Brueseke, 2014). LSystem uses mobile cloud computing and the multitude of computing resources archived in the cloud in an effective agile manner.

The MAFFS Retardant Drop Log Application

The LSystem uses client-server architecture. A client computer (laptop, desktop or iPad) is used to interact with servers located in the cloud. In this specific implementation, Microsoft Azure is used as the cloud service provider to enable a web server and a database server.

Client, Server and MySQL Database Server Operating Environment

MAFFS Drop Log Client is designed to run on all popular variants of web browsers, including Microsoft Internet Explorer, Google Chrome, Apple Safari, and Mozilla Firefox.

MAFFS Drop Log Server runs the MySQL Database Management Server, Apache Web Server, PHP code interpreter, and server-side application scripts on a Microsoft Windows Server 2012 foundation, hosted virtually on the Microsoft Azure cloud service provider.

MAFFS Drop Log Database Server is a MySQL database used in the creation and maintenance of the MAFFS Drop Log database.

Hardware and Software Interfaces

This application resides on a virtualized server, hosted by a cloud service provider. No additional hardware is required. The application may be installed on fixed, hard servers if required by operational security.

Server support software must meet the following requirements:

- Microsoft Server 2012
- PHP Generator for MySQL (SQL Maestro)
- The following elements are encapsulated in the Tracks Stack by Bitnami:
  - MySQL Database Management System
  - Apache Web Server
  - PHP Interpreter

Bitnami is a software-as-a-Service (SaaS) cloud service provider that provisions complete web frameworks for development purposes. Tracks is a specific application and is an example of a Bitnami stack that uses Rails, Apache, MySQL, and PHP as its development framework.

Maestro is SaaS cloud service provider that provisions SQL-related software development tools.

Client software must meet the following requirements:

- Microsoft Internet Explorer
- Google Chrome
- Apple Safari
- Mozilla Firefox

Portability

Portability is the ease with which the system can be moved from one environment (e.g., hardware, operating system, database server, tools) to another. LSystem may be moved to any cloud service provider hosting a Microsoft Windows Server environment that supports the Apache Web Server, PHP interpreter, and MySQL server.

Security Requirements

- *Access controls*. Data maintained in the MAFFS Drop Log database is unclassified, and shall be protected by username and password to thwart unauthorized alteration. Use of Secure Sockets Layer (SSL) encrypted pipelines will enhance security but are not mandated.
- *User account management.* Because simplicity is paramount in the initial release, usernames and passwords will be managed centrally by a Military Administrative Specialist or Forest Service staff member. This may be accomplished through the PHP-generator application. Usernames and passwords are maintained on the server.

The MAFFS Drop Log Database

LSystem translates a manual form, called the MAFFS Drop Log, to a MySQL Relational Database Management System (RDBMS) database. The MAFFS Drop Log is used to document the activities of a single fixed-wing aircraft throughout one day of wildfire firefighting operations. A sortie is the result of a request by the incident. Many aircraft can fly to the incident, each having an Aircraft Commander flying it.

Drop Log Database Entity Relationship Diagram

A relational database is made up of entities, attributes, and relationships. This is graphically represented by a diagram that helps a developer to correctly design the associated database. Once the entity relationship diagram (ERD) is defined, the database is implemented using a relational database management system (RDBMS) such as MySQL, Oracle, MS SQL, or PostgreSQL. A RDBMS stores data in tables, in which every row represents an entity or record. Each record, in turn, consists of attributes or columns. The Drop Log ERD is shown in Figure 3.

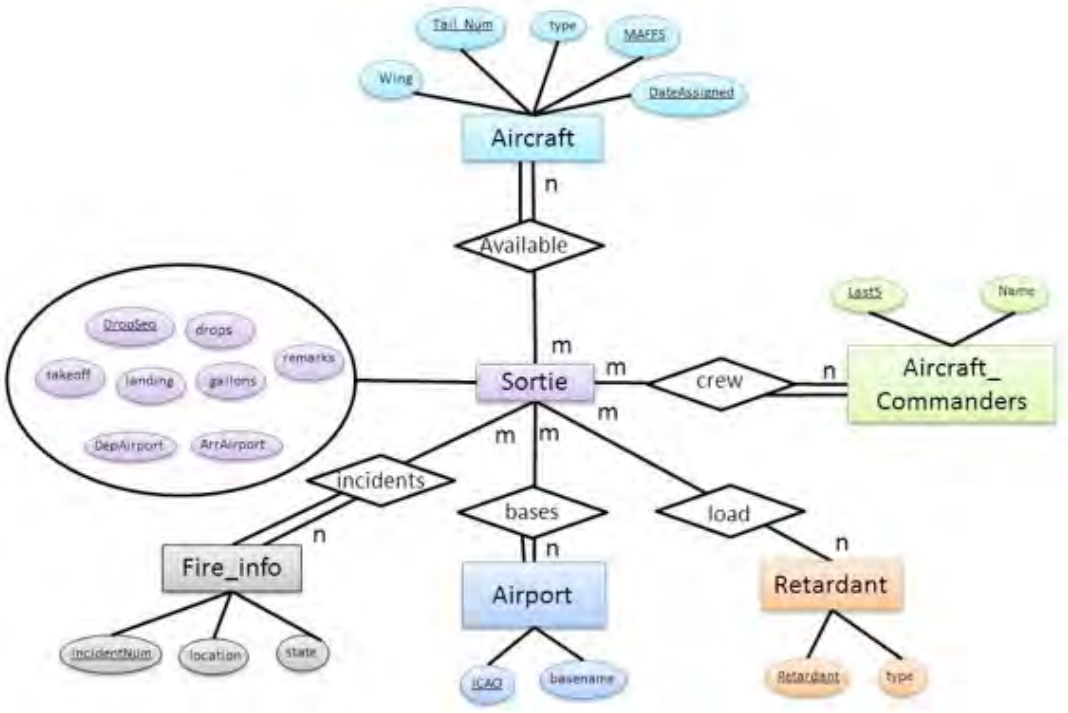


Figure 3. Drop log database entity relationship diagram.

Drop Log Normalization

To minimize database anomalies, Codd advocated imposing relational database normalization rules to a level of third normal form (3NF). "When tables are not in the third normal form, either redundant data exists in the model, or problems exist when you attempt to update the tables" (Codd, 2014, n.p.). Following these rules, the Normalized to 3NF Drop Log database is shown in Figure 4.

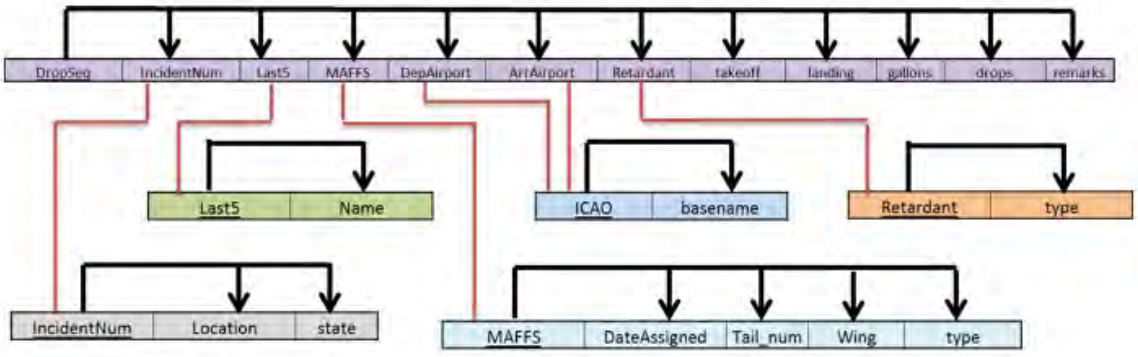
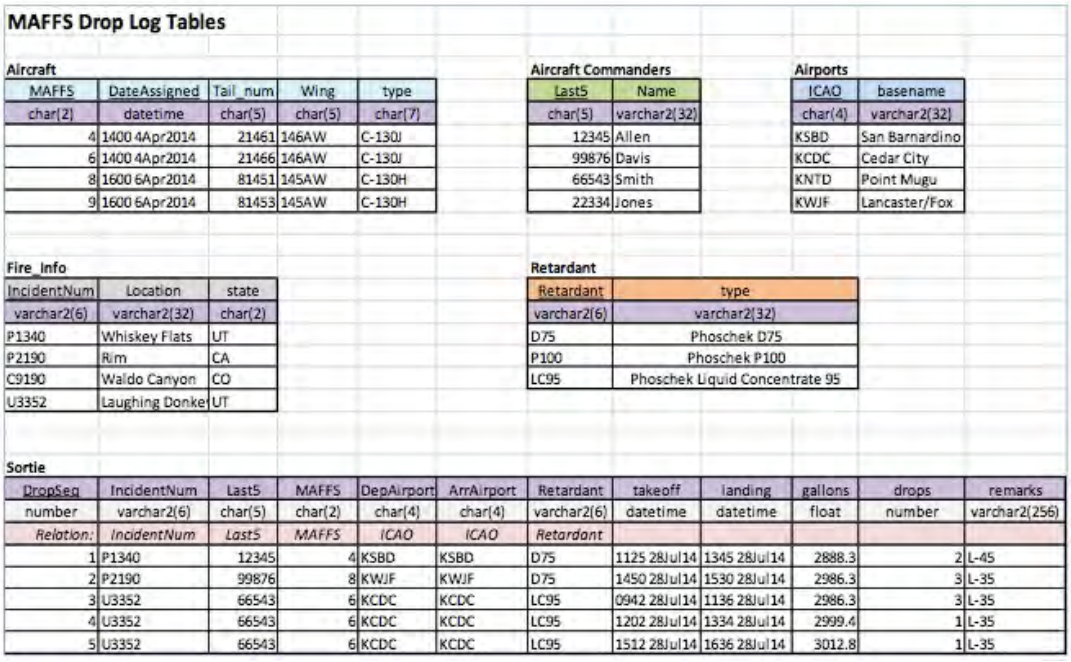


Figure 4. Drop Log database normalized to 3NF.

Representative Drop Log Database Tables

Once the Bitnami Tracks Stack is installed, the MAFFS Drop Log Database can be created. Using the phpMyAdmin application (or through a console connection to MySQL), the MySQL scripts were executed to create the database and tables. Sample data, which was then inserted using insertion scripts and query scripts, verified that the server produced the expected results shown in Figure 5.



MAFFS Drop Log Tables

Aircraft

MAFFS	DateAssigned	Tail_num	Wing	type
char(2)	datetime	char(5)	char(5)	char(7)
4	1400 4Apr2014	21461	146AW	C-130J
6	1400 4Apr2014	21466	146AW	C-130J
8	1600 6Apr2014	81451	145AW	C-130H
9	1600 6Apr2014	81453	145AW	C-130H

Aircraft Commanders

Last5	Name
char(5)	varchar2(32)
12345	Allen
99876	Davis
66543	Smith
22334	Jones

Airports

ICAO	basename
char(4)	varchar2(32)
KSBD	San Barnardino
KCDC	Cedar City
KNTD	Point Mugu
KWJF	Lancaster/Fox

Fire_Info

IncidentNum	Location	state
varchar2(6)	varchar2(32)	char(2)
P1340	Whiskey Flats	UT
P2190	Rim	CA
C9190	Waldo Canyon	CO
U3352	Laughing Donke	UT

Retardant

Retardant	type
varchar2(6)	varchar2(32)
D75	Phoschek D75
P100	Phoschek P100
LC95	Phoschek Liquid Concentrate 95

Sortie

DropSeq	IncidentNum	Last5	MAFFS	DepAirport	ArrAirport	Retardant	takeoff	landing	gallons	drops	remarks
number	varchar2(6)	char(5)	char(2)	char(4)	char(4)	varchar2(6)	datetime	datetime	float	number	varchar2(256)
Relation:	*IncidentNum*	*Last5*	*MAFFS*	*ICAO*	*ICAO*	*Retardant*					
1	P1340	12345	4	KSBD	KSBD	D75	1125 28Jul14	1345 28Jul14	2888.3	2	L-45
2	P2190	99876	8	KWJF	KWJF	D75	1450 28Jul14	1530 28Jul14	2986.3	3	L-35
3	U3352	66543	6	KCDC	KCDC	LC95	0942 28Jul14	1136 28Jul14	2986.3	3	L-35
4	U3352	66543	6	KCDC	KCDC	LC95	1202 28Jul14	1334 28Jul14	2999.4	1	L-35
5	U3352	66543	6	KCDC	KCDC	LC95	1512 28Jul14	1636 28Jul14	3012.8	1	L-35

Figure 5. Representative Drop Log database tables.

LSystem Implementation

The LSystem was designed using the OPEN Process Framework standards that include Use Case Modeling Guidelines, as well as System Requirements Specification Content, Inspection Checklist, and Template (OPEN Process Framework, 2014; IEEE Standards Association, 2002; IEEE Standards Association, 2008; NASA, 2005; NASA, 2014).

1. Secure an Account on Microsoft Azure

The MAFFS Drop Log relies on the third-party, platform-as-a-service (PaaS) provider Microsoft Azure. User account creation was straightforward and as outlined on the Microsoft Azure website (http://azure.microsoft.com/). A free-trial account was created for the development of the project application.

2. Create a Microsoft Server 2012 Virtual Machine on Azure

Once the Azure account is created, the administrator logs in and creates a new Virtual Machine. From the available images, Windows Server Essentials Experience was selected. This version

seemed well equipped for the project. Creating the server instance was fairly straightforward. During the test-and-evaluation process, it was determined that a shared processor did not have enough capacity to satisfy the development phase. It is likely that a deployed system, sharing a single processor, would meet the requirements. During development, however, a single, dedicated processor reduced development time and proved to be necessary.

Once the MS Server 2012 was instantiated and executing, a connection was made using the Microsoft Remote Desktop Connection application to access the MS Server 2012 virtual machine.

3. Install the Bitnami Track Stack into the MS Server 2012 Instance

From within the Remote Desktop Connection, the Mozilla Firefox web browser and Notepad++ text editor applications were installed to speed and facilitate development. Using Mozilla Firefox, and the cloud SaaS, Bitnami Tracks Stack was downloaded from https://bitnami.com/ and installed.

Once installed, the Bitnami Tracks application is started. This starts the MySQL database server, as well as the Apache web server behind the scenes. The PHP interpreter is also quietly started. The Tracks application can be executed once the installation is complete, to verify that each sub-server is executing.

4. Create the Drop Log Database Using SQL Scripts

Structured Query Language (SQL), is a computer scripting language used to operate on relational databases with a set of operators based on Codd's relational calculus to define and manipulate data elements, including the script operators needed to populate the tables with data. SQL was used with the MySQL database server initiated in the previous step.

5. Install and Run the PHP Generator for MySQL from SQL Maestro

After the database was created, the application was downloaded and executed to generate a web-based front end for data entry and report generation. The PHP application from the cloud SaaS, SQL Maestro (www.sqlmaestro.com) called "PHP Generator for MySQL," was downloaded at no charge.

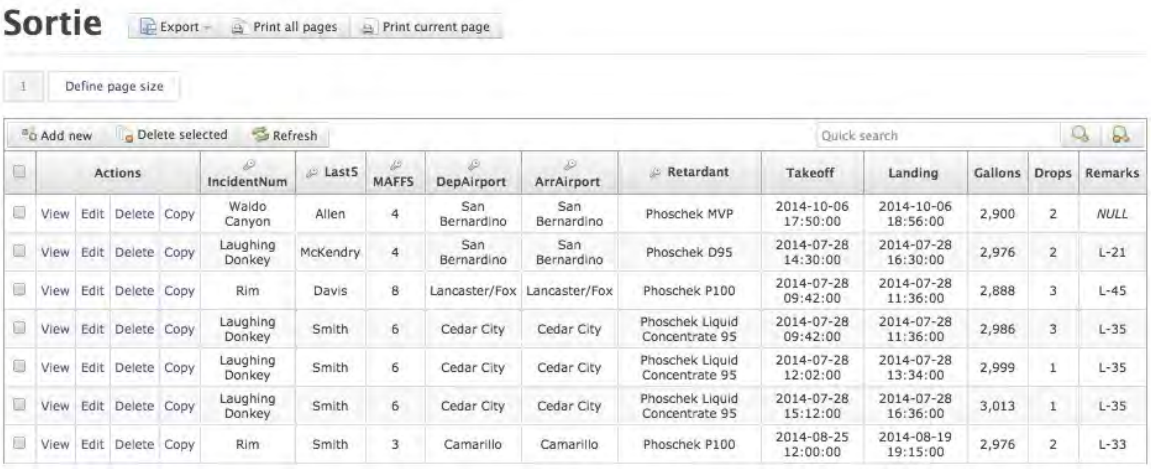
LSystem Demonstration

The MAFFS Drop Log application is accessed through a standard web browser using the address of the server. A variety of browsers, running on several different platforms, were tested. These include Microsoft Internet Explorer, Apple Safari, and Google Chrome, running on Windows versions 7 and 8, Apple OSX 10, and on an Apple iPad and iPhone running iOS version 7.

The application is structured such that a table of data is selected through a link on the upper left of the screen. Once selected, data in that table may be added, changed, or deleted. As an example, selecting *Aircraft* brings up the list of aircraft currently stored in the database. A new aircraft can be added, or existing aircraft may be edited or deleted. This process is duplicated with each of the other tables.

The tables accessible from the links on the left side of the page include *Aircraft*, *Aircraft Commanders*, *Airports*, *Fire Info*, *Retardant*, and *Sortie*.

Two queries are available, *Drop Log Format* and *Utah Fire Info*. These queries demonstrate how data may be retrieved from multiple tables to produce a single, more readable output. The Drop Log Format mirrors the manual Drop Log form from which the project is rooted. The screen is shown in Figure 6.



Sortie

Export Print all pages Print current page

1 Define page size

Add new Delete selected Refresh Quick search

	Actions				IncidentNum	Last5	MAFFS	DepAirport	ArrAirport	Retardant	Takeoff	Landing	Gallons	Drops	Remarks
	View	Edit	Delete	Copy	Waldo Canyon	Allen	4	San Bernardino	San Bernardino	Phoschek MVP	2014-10-06 17:50:00	2014-10-06 18:56:00	2,900	2	*NULL*
	View	Edit	Delete	Copy	Laughing Donkey	McKendry	4	San Bernardino	San Bernardino	Phoschek D95	2014-07-28 14:30:00	2014-07-28 16:30:00	2,976	2	L-21
	View	Edit	Delete	Copy	Rim	Davis	8	Lancaster/Fox	Lancaster/Fox	Phoschek P100	2014-07-28 09:42:00	2014-07-28 11:36:00	2,888	3	L-45
	View	Edit	Delete	Copy	Laughing Donkey	Smith	6	Cedar City	Cedar City	Phoschek Liquid Concentrate 95	2014-07-28 09:42:00	2014-07-28 11:36:00	2,986	3	L-35
	View	Edit	Delete	Copy	Laughing Donkey	Smith	6	Cedar City	Cedar City	Phoschek Liquid Concentrate 95	2014-07-28 12:02:00	2014-07-28 13:34:00	2,999	1	L-35
	View	Edit	Delete	Copy	Laughing Donkey	Smith	6	Cedar City	Cedar City	Phoschek Liquid Concentrate 95	2014-07-28 15:12:00	2014-07-28 16:36:00	3,013	1	L-35
	View	Edit	Delete	Copy	Rim	Smith	3	Camarillo	Camarillo	Phoschek P100	2014-08-25 12:00:00	2014-08-19 19:15:00	2,976	2	L-33

Figure 6. All sortie information.

Future Research and Development

The MAFFS Drop Log application solves a simple problem, converting a manual form into a digital data entry application. The information to be input is determined during flight operations, when aerial firefighting aircraft are tasked to provide retardant on wildfires. Throughout the day, flight crewmembers record information as it happens.

Two significant future enhancements to the MAFFS Drop Log application are support for mobile devices and support for saving transactions when not connected to a network.

Conclusion

The LSystem was a collaborative research initiative that used leading-edge, innovative teaching and technological techniques: a collaboratory, agile project development, and state-of-the-art cloud technologies. This project, completed in two months, is an example of not only research but beneficial implementation of innovative pedagogy and experiential learning to create a useful product.

Student success in the NU one-course-per-month modality was enhanced by agile use of technology. Specific tools that proved extremely productive were virtualization, Ruby on Rails framework, and cloud infrastructures.

The objective of this research project was to implement a digital capture of MAFFS Drop Log data satisfying the 12 objectives previously listed. All 12 objectives were accomplished.

Regarding the specific research objectives of using leading-edge and innovative teaching and technological techniques, these also were most successful and are recommended for further utilization.

Collaboratory ("working together apart")

The client, Colonel B. Kelly, was continuously involved by the Project Lead, Allen, in the development process, which ensured a successful project delivery. An industry collaborator, Spork Labs Ltd., provided fundamental guidance in utilizing Bitnami stacks for Ruby on Rails framework training at a critical stage. The MS Computer Science Lead Faculty, Dr. Dey, provided guidance and counsel in a timely manner. Additionally, the manner in which the students in DAT605 worked as a team under the direction of the project lead was most collaborative.

Agile Project Development

Allen, the project lead, utilized agile concepts in working with both the client, Colonel B. Kelly, and Allen's instructor, Dr. Romney. Challenges were addressed, and modifications were made dynamically.

State-of-the-Art Cloud Technologies

Cloud technologies were discovered by the project lead, analyzed, and then selected in accordance with the agile process.

The synergy between collaboration, agility, and cloud produced a remarkable exercise in innovative research in both pedagogy and technology to produce a very functional product in the LSystem.

Acknowledgements

The authors are grateful to the National University administration, staff, and faculty for providing support for using cloud computing resources in the SOEC computing curricula. The authors acknowledge the assistance of Jorge Balares and Steven McKendry in the team contribution that each made in the DAT605 initial Drop Log project; and the continued collaboration provided by Spork Labs Ltd in Rails technology is appreciated.

Glossary of Information Technology and Other Terminology

AEG-WFF. Aerospace Expeditionary Group, Wildland Fire Fighting, is the military organization created to support the aerial firefighting program.

Agile. Ability to move quickly as applied to pedagogy, delivery, development, and management.

Authentication. Validating identity of a person or object.

Azure. Microsoft cloud service provider that provides both PaaS and IaaS services that support many programming languages, tools, and frameworks.

C2 Center. AEG Command and Control Center. It is the responsibility of C2 Center staff to collect, record, and audit information related to all aspects of aerial firefighting activity.

Cloud. The Internet or network of computing resources. May be either public or private.

Cloud computing. The delivery of computing resources or services over the Internet.

Collaboratory. Coined by the National Science Foundation to identify a laboratory consisting of collaborating colleagues.

Cyber security. The discipline of securing computer resources and information.

Firewall. A hardware or software system designed to prevent unauthorized access to an infrastructure.

Hypervisor. Computer software or hardware that manages and executes virtual machines.

IaaS. Infrastructure as a Service cloud resource. Azure is an example of an IaaS. The provisioning of virtual machines with Microsoft operating systems, as its first priority, is one of its services.

Infrastructure. Physical computing hardware and resources that are part of a network, a cloud, or the Internet.

LSystem. MAFFS Drop Log Application System prototype developed as a National University Master of Science in the Computer Science program of the School of Engineering and Computing.

MAFFS. Modular Airborne Fire Fighting System program of the U.S. Department of Defense in support of the U.S. Forest Service that is part of the Department of Agriculture.

MDLAPS. MAFFS Drop Log Application Project Specification of the LSystem.

Mobile cloud computing. Comprises three heterogeneous domains: mobile computing, cloud computing, and wireless networks.

Mobile device. A portable computing device that is most often hand held, such as an iPad, notebook, or smartphone that uses a wireless network.

Module. A procedure or process.

MySQL. An open-source relational database management system that uses tables of rows and columns of data, and defines the relationship of the data elements.

Normalization. E. F. Codd established a number of rules for a RDBMS that eliminate data anomalies such as data redundancy that are referred to as RDBMS Normalization to at least a Third Normal Form (3NF) level.

OPF. OPEN Process Framework standards provide Use Case Modeling Guidelines, as well as System Requirements Specification Content, Inspection Checklist, and Template.

PaaS. Platform-as-a-service cloud resource. Azure is an example of a PaaS. The provisioning of MySQL database servers is one of its services. Ruby on Rails as a programming framework is one of its services. Bitnami that uses Rails is one of its services.

PHP. A server-side computer scripting language used for web development.

Private cloud. A cloud that is private to an enterprise and may be physically local to the user.

Public cloud. A cloud available to the public at large and normally physically remote from the user.

RDBMS. Relational database management system that follows the rules of Codd's Relational Calculus and uses tables with rows (entities) and columns (attributes) that are linked by relations.

SaaS. Software-as-a-service cloud service provider. Bitnami is an example of a SaaS.

SQL. Structured Query Language, a computer scripting language used to operate on relational databases with a set of operators based on Codd's relational calculus to define and manipulate data elements, and to generate reports of the resulting operations.

SSL. Secure Sockets Layer encrypted tunnel for all LSystem operations.

Stack. A software configuration that contains all of the software modules to provide a development environment. Such modules include an operating system, web server, database server, and development resources. Bitnami is a cloud service provider that facilitates stacks of various configurations. Tracks is an example of a Bitnami stack that uses Rails, Apache, MySQL, and PHP as its development framework.

Virtual machine. An instance or emulation of a real, physical computer with its own segmented, private, unshared operating system and memory space.

Virtual private network (VPN). A method for providing secure, encrypted communication for a remote computing device over the Internet.

Virtualization. The act of using a hypervisor and virtual machines to provide a virtual, non-physical computing resource environment.

VM. A virtual machine.

Web 2.0. The second stage of implementation of the World Wide Web or Internet, characterized by social networking and general collaboration.

Wi-Fi. Wireless technology that uses high-frequency radio waves to send and receive data and normally connects with the Internet.

Wildfire. A wilderness-area fire that is wind driven, fueled by vegetation, and distinguished by its extensive size and speed of propagation.

Wireless network. A computing infrastructure that supports cable-less connectivity of computing and mobile devices, frequently through Wi-Fi technology.

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Communication, Collaboration and Relationships in the Online College Class: Instructors' Perceptions

Peter Serdyukov & Cynthia Sistek-Chandler

Abstract
Online learning has become well established in the first decade of the 21st century as an effective and convenient mode of education for a rapidly growing number of university students. Along with offering many advantages for the learners, it has provided, regrettably, limited interaction among the participants, despite an increasing integration of new communication technologies in the online courseware. This research investigates the role of socialization and interactivity in online university classes and, through instructors' perceptions, attempts to understand the current trends in online education while outlining future developments in this area.

Key Words
Online education, faculty perceptions, social efficacy, communication, collaboration, interactive learning

Introduction

Online learning is by definition a form of independent learning. Research, however, indicates that effective online learning can be promoted by interaction, communication, and collaboration among students, as well as with instructors (Haythornthwaite & Andrews, 2011; An, Kim, & Kim, 2008; Siemens, 2005; Rourke & Anderson, 2002). Online education should, therefore, be built on a highly interactive model, one that promotes social presence, active communication, and collaboration; helps establish relationships among all stakeholders; and encourages the creation of a learning community. Application of such an approach, for instance, a Community of Inquiry, or CoI (Akoyol & Garrison, 2011), may lead to higher levels of learning and satisfaction in an online course with a focus on community. Palloff and Pratt (2001) indicate that by creating and sustaining a community for learning, overall satisfaction increases when the community of the learning group--that is, students and instructor--is engaged. Learning Management Systems (LMS), such as Blackboard, Moodle, and Desire2Learn—three of the most widely utilized systems (Green, 2013)—thus far have limited capacity for interaction among the participants of organized learning.

In fact, learning, online or onsite is not only best facilitated by strong instructor presence but more importantly, is dependent upon the instructor, who guides the learner through a variety of cognitive and social activities. Vygotsky's social learning theory (1987), and Lave and Wenger's situated learning approach (1991) suggest that the learning environment, whether physical or virtual, needs to include a social component. In an online environment, socialization is accomplished through communication tools such as email, threaded discussions, and different web-based synchronous activities. Still, as research and practice demonstrate, these tools are insufficient to achieve the optimum level of social activities to promote learning. Much in initiating and maintaining this important activity depends on the instructor.

Interactive Online Learning

With the advent of Web 2.0 and other collaborative online tools, an increased focus on collaboration, socialization, and group work in online university programs is noticeable; yet, students still report social isolation in online classes and, at the same time, exhibit a growing

inclination to conduct their work independently without input from their peers or involvement in group work (Serdyukov & Hill, 2013). Bolliger and Erichsen (2011), in particular, reported that international students experienced high levels of isolation both academically and socially. Perceptions of online learning from the student perspective have continued to report the experience as an isolated and independent form of learning. The growth of class community and intensification of student engagement are closely related to one another. Students who feel a sense of connectedness and psychological closeness, rather than isolation, are better prepared to become more actively involved with online learning and the resulting higher order thinking and knowledge building (Baker, 2014; Engstrom, Santo, & Yost, 2008).

Despite the feeling of isolation in an online environment, however, students in university classes still try to refrain from collaboration and prefer to work independently rather than in groups. Serdyukov and Hill (2013) queried university students on learning preferences regarding independent learning and collaborative activities. When offered a choice between taking university courses and studying independently, 64.9% of students selected university courses, while only 24.3% indicated they could choose independent study and the rest showed no preference (p. 61). Thus, working adult students are not generally enthusiastic about learning independently; moreover, when asked if they prefer to learn independently or to collaborate with their peers in a university class, 70.3% of students stated they preferred to study independently, while only 18.9% liked to collaborate with their peers. These data are indicative of students' attitude towards collaboration in online learning. Another study conducted by Poellhuber, Anderson, and Roy (2011) reported a higher percentage of students—38.4% of respondents—as "interested or very interested in collaborating with peers in their distance courses" (p. 110), which still leaves the majority of students outside the collaboration.

The continued desire to work independently in online classes has generated a serious problem for both instructors and students in present-day online classes. Learning, as noted earlier, is a social process involving continuous and varied interactions within the student group. Interactivity is essential for deep, meaningful learning. Early research in technology-based education has identified three kinds of interactivity that support learning in online courses: interaction with content, when learners access, manipulate, synthesize, and communicate content information; interaction with instructors, in which learners communicate with and receive feedback from their instructors; and interaction with classmates, in which learners communicate with each other about content to create an active learning community (Moore, 1989).

According to Swan (2004), in the relationship between the learner, the course content, his or her peers in the college group, and with the instructor, the student's interaction with the content remains strong, while interaction with the two major live participants, the peers and the instructor, has been diminishing. "Computers made us lose the ability to enter into spontaneous interaction with real people" (Stroll, as cited in Hargreaves, 2003, p. 25). As shown in the study by Serdyukov and Hill (2013), when working in groups, students have little confidence in their potential partners and are upset about losing their chance to earn a top grade if they team up with less proficient peers (p. 61). Hargreaves pointed to this phenomenon, expressing concern over "school systems driven by performance results at the expense of relationships" (Hargreaves, 2003, p. 26). Why does it happen? Maybe because authentic human relationships are more complicated, unpredictable, demanding, time consuming, and reliant on trust in the partners? In an attempt to avoid human interactions, virtual or in person, students prefer to engage primarily with the content, which is not only necessary, but also safe and straightforward.

Interaction with the content, while static, however, is neither easy nor sufficient, especially when students often come to college with an inadequate knowledge base. Some students enter the university needing guidance, support, and mentoring from their instructor. Yalof (2013), in a grounded research study of online learners, examined the main impediments to studying online and reported that students feel a sense of isolation and lack of access to support systems, due to navigating through the complex requirements of their online programs.

Success in education depends, besides social learning and collaboration, to a large extent on relationships, and empathy building. Student accomplishments are greatly affected by the level of their engagement in communication and collaboration with their peers and instructors. "Engagement is the amalgamation of a number of distinct elements including active learning, collaborative learning, participation, communication among teachers and students and students feeling legitimated and supported" (Beer, Clark, & Jones, 2010, p. 76). Research shows that students who collaborate and even ask for help tend to obtain greater success in the online learning environment (Artino, 2008). Research by Serdyukov and Serdyukova (2009) demonstrates a correlation between student outcomes and the volume and frequency of their participation in course communication (via threaded discussions), as well as instructor's involvement: The more the instructor is involved, the more students engage in the class discussions, and the better the student outcomes. Liu, Magjuka, Bonk, and Lee (2007) found that instructors who facilitate a sense of community and student engagement significantly affect student satisfaction and quality of online learning.

The need for interaction is certainly realized by the online course developers and, especially, by the instructors. In addition to continuous engagement with the learning materials, assignments, course support materials, and external web-based resources, students in online courses traditionally participate in threaded discussions and chats and use email communication, which provides text-based interaction among students and with the instructor. This kind of text-only communication is insufficient to ensure effective, multimodal interaction in the class. Thus, a new trend has evolved to add more online synchronous communication through tools such as Collaborate (Blackboard), Adobe Connect, and other web-conferencing software. These tools allow for real-time Voice over Internet Protocol (VoIP) to promote live meetings and create a sense of immediacy in online classes. Incorporating advanced communication tools has been a recent innovation, which will be discussed later in this article. Many institutions are moving toward a blended model where the online class includes one or more face-to-face classroom sessions. For an online institution, however, it imposes limitations on student flexibility and convenience of learning due to the requirement to attend synchronous meetings on the college campus at an appointed time. Therefore, it does not hold great appeal for working adult learners who favor asynchronous communication, which grants them flexibility to adapt learning to their busy lifestyles.

Technological innovations leading to cloud-based collaborative learning, such as blogs, wikis, social media, and Web 2.0 tools, do offer communication and collaboration opportunities in the online environment. "The term 'social media technology' (SMT) refers to web-based and mobile applications that allow individuals and organizations to create, engage, and share new user-generated or existing content, in digital environments through multi-way" (Davis, Deil-Amen, Rios-Aguilar, & Conche, 2012, p. 1). Research indicates a growth in student socialization on and outside the campus and creations of virtual communities and spaces online for students to congregate (Sendall, Ceccucci, &Peslak, 2008; Poellhuber et al., 2011). Still, computer-mediated interactions do not amount to "real," personal, closer communication, thus continuing to impair

student learning. Handy, according to Hargreaves, observed that, "fun they may be, these virtual communities create an illusion of intimacy and a pretense of community' (Hargreaves, 2003, p. 25), so do they offer a substitute for real conversation? While agreeing with Handy, the present authors believe that to ensure students' effective learning outcomes, working online learning communities must be developed and students' socialization and collaboration must be increased. Social networking, for one, which is rapidly entangling university students in academic settings, involves not only communication but also collaboration, cooperation, and teamwork.

For active interactions in the student group to develop, the emergence of close relationships among them remains a critical condition. A failure of social relationships and a corresponding loss of the sense of community that is usually present on a traditional campus is noted as one of the potential negative effects of online courses (Hiltz, 1998). Relationships develop when people have a common physical place to meet, a mutual reason to be together, shared goals to engage in some activity, a strong motivation, and favorable conditions for joint activities. People need opportunities to get together, to rub shoulders, to experience commonality, and to learn to trust each other when combining their efforts and resources to enjoy the benefits of collective work. Do online classes offer such opportunities? Not often, unfortunately, because in organized university classes someone needs to arrange and facilitate communication and collaboration in the class and construct conditions for the relationships to develop. The main role in this task definitely belongs to the universities and instructors.

Universities provide online classes through a learning management system (Blackboard, eCollege, Moodle, or MOOCs), tools, materials, communication channels, instructors, support, and resources. Instructors, in turn, effectuate facilitation, organize and maintain communication and collaboration in the class, and provide guidance, ongoing support, feedback, and individual consultations.

While physical conditions are necessary for establishing and supporting communication and collaboration, still more depends on the enthusiasm, dispositions, and professional qualifications of online instructors who make learning possible. The role of the instructor is paramount to increasing effectiveness of online education (Barana, Correiab, & Thompson, 2011; Hill & Serdyukov, 2010).

Interactive Learning: Instructor Roles

The new, technology-based environment has drastically transformed traditional instructor roles. In online education, the role of the instructor is even more critical than in a traditional campus-based classroom, as the instructor is only virtually present in the online classroom. Hence students do not see the instructor and are not obliged by relationships. At the same time, the instructor has to be continuously "visible" in the online classroom and help learners overcome numerous barriers caused by course assignments, technology, time management, separation from the class, and the way interactions with learners and the instructor occur within that environment. The instructor has to maintain an active online learning environment, which embraces interactions, participation, support, guidance, and other functions. So the online instructor needs to take a multi-dimensional role; and to be effective, the instructor is expected to possess a wider and varied range of competencies (Bawane & Spector, 2009; Bailie, 2011). An instructor can be content facilitator, technologist, designer, manager/administrator, process facilitator,

adviser/counselor, assessor, and researcher (Goodyear, Salmon, Spector, Steeples, & Tickner, 2001).

What does the instructor commonly do in online classes? What is facilitation; how does it support communication and relationships in the class? How do instructors actually teach online? While online learning is becoming more individualized and more autonomous, the role of the instructor, especially in organized college classes, becomes more intricate, more democratic, and more sensible, but it still remains crucial.

Smith (2005) identifies and describes 51 competencies needed by online instructors, among them:

1. Create a warm and inviting atmosphere that promotes the development of a sense of community among participants.
2. Develop reciprocity and cooperation among students.
3. Develop relationships.
4. Encourage contacts between students and faculty.
5. Mandate participation. Step in and set limits if participation wanes or if the conversation is headed in the wrong direction.
6. Model good participation.
7. Teach students about online learning.
8. Most of all have fun and open yourself to learning as much from your students as they will learn from one another and from you! (Smith, 2005)

This is all essential for the success of online learning. A competent online instructor understands the social nature of the classroom and how it can contribute to the success of the students; the instructor applies and promotes interactivity with students and between students. Such an understanding is needed to effectively reduce student feelings of isolation, increase active learning, and develop synergetic relationships in the classroom (Varvel, 2006).

Mandating and, at the same time, modeling good interaction seem to be the two most effective ways to develop and maintain communication and collaboration in an online class (Hill & Serdyukov, 2010). Modeling is executed by continuous, genuine, and interested engagement, expeditious feedback and response to student questions and concerns, and personal, informal mode of communication. The instructor has to perpetually indicate and demonstrate presence in the online classroom.

Most instructors do their job professionally and responsibly; however, in too many instances they are not fully engaged in the process, do not provide sufficient support and relationships, and are slow in communication and late in response and grading:

> Undisciplined or uninformed instructors may demonstrate minimal formal involvement in the discussions, posting a few supportive messages without analyzing students' posts and making in-depth comments. They do not contribute their content expertise and fail to engage students in higher-level thinking. A few believe that a . . . discussion is a self-sustaining activity. They participate minimally, leaving the majority or even all of the work to students. (Serdyukov & Hill, 2009, p. 1429)

Such instructors need more structure, guidance, peer review, departmental control, high responsibility to manage online courses more effectively, and constant professional development so as to be focused on continuous improvement of the craft of online teaching.

Pilot Study: Perceptions from Professors

To investigate socialization, relationships, and collaboration in online courses, the authors conducted a pilot study based on a specially designed survey, which was intended to gather and report on the perceptions of online teaching faculty regarding these factors. The results of the pilot study, which surveyed a group of faculty in the fall of 2012, are presented herein.

The purpose of the research was to investigate whether online learning has the potential to develop more real, personal, and emotional interactions, as well as to explore the likelihood of developing effective relationships in an online class. The instrument of research was a survey created using My-eCoach, which contained a 25-item online questionnaire. The survey was sent to a faculty listserv at National University and to the community at large, including a consortium of online educators. Questions were formulated using several question types (Likert, open ended, and short answer) and were used to identify instructors' responses, perceptions, and opinions about their individual online teaching experience and their interactions with their students. The pilot study included a total of 45 respondents from six different disciplines, 35 from the host institution and 10 faculty members from other universities. Of the 45 respondents, 97% were seasoned professionals with 4 or more years of online teaching experience. Thirty of them (68%), which constituted the majority of the sample, had 8 or more years of university teaching experience, while 14 (29%) counted between 4 and 7 years of online teaching experience.

As the research focused on interactions, socialization, and relationships in an online class, the major questions were as follows.

Similarities and Differences Between Online and Onsite Classes

The results of our research demonstrated that the majority of instructors (62%) believed online learning is more real than virtual; fewer (50%) believed it is more personal than impersonal; and fewer still (48%) believed it is more emotionally charged than emotionless. These impressions may be due to the faculty perception that the mode of education (more real than virtual), its personal character (due to the participation of the instructor and the students), and emotionality are key classroom components that can vary, depending on the learning environment. It is an interesting finding, as the goals, objectives and content of learning remain the same in both onsite and online classes.

Many of the faculty queried in this study also believed online classes are like onsite classes, which is supported by some studies that show no significant difference between onsite and online instruction (Johnson, Aragon, Shaik, and Palma-Rivas, 2000; Derwin, 2009). It is posited, nevertheless, that the environment, medium, modality, and manner of interaction are, in fact, different. That might be why many instructors still see online learning as impersonal, emotionless, and virtual, rather than real. Is this difference of opinions a result of educators' adaptation to the new media, or is it due in part to self-awareness? Do students regard their peers and instructors as live beings or as fictitious characters in a computer game called a "course"? Perception of online learning as real or virtual, close or distant, personal or impersonal, may significantly affect the way the instructor interacts with students, and also how students interact with the instructor and peers.

The majority of the instructors believed online learning is more independent and less social that the traditional one: 64% stated it is more independent than collaborative; 48% believed it is more asocial than social. A little over half of the respondents (52%) listed threaded discussion

tools as regularly used to promote social interaction, besides being a forum for debating the content. Remarkably, all respondents reported that they promote interactivity and socialization through the use of synchronous (text-based) discussion, such as chat, or synchronous/Voice-over-Internet-Protocol (VoIP) enabled tools.

These beliefs reflect a "perceived" reality in online classes which may influence the teaching, as well as communication and collaboration among students. For instance, an instructor who believes the learning is by nature independent may not apply sufficient efforts to organize group activities in the class or will not provide students with the level of support they may actually need.

Collaboration and Cooperation

Instructors generally believe collaboration has a good potential in online classes. 69% of respondents stated that online learning can include group work, whereas 28% regarded it as mostly an independent activity. This latter figure significantly differs from the previous data, which indicates 64% of instructors believed online learning is mainly an independent activity. This contradiction is difficult to explain. A second question from the survey also asked whether or not they perceived that their students like to collaborate with class members in an online environment. In this case, 70% of instructors believed their students like to collaborate, while 25% reported their student did not. Previous research (Serdyukov & Hill 2013), however, does not confirm this claim, as over 70% of students surveyed stated that they try to avoid collaboration and cooperation in online classes. When the question is formulated differently, 93% of respondents believe online learning allows for collaboration and cooperation among students. It looks like instructors highly regard the potential of online classes for teamwork, even if it is not often realized.

Many factors were found that support integration of collaborative activities in an online class; however, several respondents felt collaboration is a challenge in the online environment. Reasons ranged from time deficit and lack of trust for their fellow online classmates, to the students' expressed desire to work independently, e.g., "In my opinion, collaboration happens only if the instructor encourages or demands it and if it is left to [his/her] own devices, but if [collaborative assignments] remain ungraded it would not happen." Several respondents reported a low level of student participation when engaged in teamwork or collaborative work groups: "Good students become frustrated with those who lack motivation, or, in many instances, do not possess higher skills [commensurate to the skills possessed by good students who are engaged and cooperative]. One online instructor reported that when students self-select to study fully online, it was the instructor's belief that the online students are more willing to work independently. This self-selection of online classes indicates that some students would rather take a face-to-face (F2F) class if it were made available, while other students prefer this format because they favor working alone.

While there is a general understanding among instructors that engagement in collaborative activities for the most part takes place more frequently in onsite classes than in online classes, 91% shared useful strategies for successful online engagement and collaboration, and only 9% reported that they either do not require group work or have altogether stopped group work online.

Relationships in the Online Class

Analysis of the survey indicates that faculties in general appreciate the importance of relationships in a class. It is remarkable that 85% of respondents believed that relationships in the class affect the outcome of student learning. Sixty-seven percent agreed that online learning promotes relationships in the class, while 31% disagreed; this reflected previous opinions of the social vs. asocial character of this educational format. 88% believed online classes should be personalized in the way that students develop closer relationships in the class with peers and instructor; 86% believed instructors need to establish empathy, emotions, and personal relationships in an online class. This is an important recommendation for practicing online educators. Regrettably, the reality of online education is that the emergence of relationships among students and with the instructor are rare. Learning communities develop over time, and online learning does not always afford time to develop the optimal community.

It is critical, nevertheless, that the instructors develop some kind of a relationship (rapport) with their online class and establish personal contact with individual students. It is also posited that students need to engage in continuous civil, intellectual, scholarly, and professional discourse with their peers and with their instructors. In a study by Upkopodu (2008), online students identified commonly shared attributes of the course that increased their overall engagement and relationships in their online class: Students positively reacted to using threaded discussions and partner-shared learning activities; favorably commented on course structure containing the 3Rs (rigor, relevance, and relationships); and enthusiastically engaged in a variety of writing activities that allowed for interaction, e.g., making pre-post narrative inquiries and writing or reading response papers.

Online Students

Do we deal with the same types of students in online as in onsite classes? Fifty-two percent of instructors believed there are differences between online students and students in live, face-to-face classrooms; 38% saw no difference. Forty-three percent believed that students lose some social, civic, personal, humanistic traits and become estranged, distanced, impersonal, and unemotional in an online class, while 57% did not see this. Clearly this indicates that the online environment and interaction medium have an impact on both instructors and students. This loss of the ability to be social online may be noticed in student distancing from the instructor and peers and their preference of independent work, rather than collaboration in the course; the loss of some social traits is manifested, in particular, through the non-use of the collaborative tools.

So, the overwhelming majority of instructors in this study believed, on the one hand, in the power of personal relationships in an online class and considered that they should develop them; many, on the other hand, were still unsure that online learning promotes relationships and creates an environment that blends the intellectual and formalized learning with the social learning. Even fewer knew how to establish and maintain relationships.

Why did many instructors believe online learning is impersonal, emotionless and more virtual than not? Why were many of them uncertain that online learning could promote relationships and provide positive social experiences? Why did there continue to be a belief that online learning is intended chiefly for independent study? Does this opinion reflect the real essence of web-based learning? Is it cultural, or is this withdrawal perception based on the current state of online education? These questions anticipate answers. In any case, while

appreciating the value of group work, instructors need to make more real efforts to enhance communication and collaboration in their classes, to develop relationships, and to engage students in teamwork.

Effective Student Collaboration

The main factors identified by the surveyed instructors as necessary for effective student collaboration in an online class were as follows:

1. Instructor's personal one-on-one contact with students via electronic tools (email, Skype, telephone, ClassLivePro, social media, etc.), and students' personal relationships with peers and the instructor.
2. Instructor's individual teaching style, methodology, role modeling, and persistence to make students work in teams and collaborate.
3. Students' disposition and desire to learn from others, to help and share, and experience empathy in interactions.
4. Students' confidence in the partners and trust established between team members.

From experience we know that confidence and trust develops in close, face-to-face teamwork. Although we cannot tell students to share and care about others, the online environment needs to allow experiences that simulate trust, empathy, collaboration, sharing, and caring. However, we should expect instructors to have more communications with the students, model effective interaction, develop relationships with students, and make working in teams for the expressed purpose of collaboration a standard practice.

Synchronous, Asynchronous, and Collaborative Tools

With increased sophistication of VoIP tools and real-time desktop video conferencing, and with virtual worlds and communities' becoming more "real," the need for socialization and development of relationships in online learning is increasing. All of the respondents indicated they used both synchronous and asynchronous tools in their online classes, as they complemented each other. Most instructors reported that they engaged students in a variety of interactive activities via ClassLivePro (Elluminate Live), Adobe Connect, and other web conferencing systems (Second Life, Google chats, WebEx, and others).

Along with VoIP tools, social media tools and social learning platforms were also being adopted and integrated into online education (Web 2.0, wikis, blogs, Facebook, LinkedIn, Twitter, Instagram, and photo sharing). Learning management systems, such as eCollege and Blackboard, have recently incorporated more of a "social" interface to enhance the online experience for students and for instructors. In 2012, the Office of Institutional Research and Assessment (OIRA, 2012) for the National University System conducted a survey of 336 faculty members, where 77% of them indicated they used social media tools in their personal lives, and a high number (62%) reported using online social media tools in their classrooms. The majority of them (73%) were also in agreement that social networking and community interaction are valuable in the educational setting.

Despite all of the emerging technologies and inclusion of sophisticated tools, and more technically advanced networks for transferring real-time voice and data, it remains a challenge to create an online learning environment that fosters interaction, collaboration, and developing

discourse and civility in virtual classrooms. As some respondents in the National University study reported, it was their perception that not all students want to belong to the online community; yet, when forced, they start collaborating, sharing, and interacting with others. This points to the high academic rigor set by the instructor. Palloff and Pratt (2005) indicated that creating and sustaining a community for online learning enhances student satisfaction and learning through community involvement. As a consequence, the online learning community experiences also spill over into the face-to-face everyday life of students and instructors, which may positively affect their instructional methods and teaching styles.

Suggestions for Best Practices in Enhancing the Online Environment

The data from this study, in addition to data from numerous research studies and practitioner texts from the field (Bonk & Zhang, 2006; Sloan Consortium, 2012; Sistek-Chandler, 2012), give online instructors a plethora of questions to contemplate and some sound suggestions to implement in the online class. To reiterate, the suggestions for best practices that encourage communication, collaboration, cooperation, and professional discourse shared in this article by the experienced online instructors include the following:

1. Design and prepare course syllabi, course outline, and calendar with the understanding that an online class is different from the face-to-face environment.
2. Plan for collaboration, synchronous communication, asynchronous threaded discussions and videoconferences, and opportunities for informal communication.
3. Set the tone and produce a good first impression from the start. Create and model a warm and welcoming learning environment that also establishes empathetic and humanistic relationships. Instituting a positive and mutually respectable collaborative online community overall will help to establish trust in a "cyberworld."
4. Communicate policies and online norms, including netiquette and other online ethics. Set clear expectations that students will be expected to behave in a professional manner and that collaboration and meaningful exchanges with the instructor and with peers are desirable and required.
5. Hold virtual office hours when students can talk to you directly. A quote from one of the instructors: "To increase interaction, I regularly hold office hours in Second Life. For example, if students drop by, they can join the discussion. . . others ask questions, and share information." Office hours are more informal and can be used to establish rapport and develop just-in-time, personalized coaching and mentoring, while also providing a venue for direct instruction, tutoring, and skill development (mini-lessons, clarification of coursework, or short vignettes to expand on the course content).
6. Allow for synchronous discussion in which the video and voice can be used. This is critical to the success of the online class.

Key strategies offered by respondents that encourage and engage students in collaboration in the online class are as follows:

- Demand and require group work as part of the process.
- Ask students to self-select and form groups by meeting with other students in chat, private threaded discussion rooms, or in a virtual office.

- Create a collaborative climate through Q and A and informal discussion boards (e.g., Introductions), where students can get to know each other and learn of their likes, interests, and problems.
- Use Socratic methods that help to form groups based upon student interests.
- Arrange groups by time zone and see that the groups reflect gender balance.
- Establish policies for differentiated grading that include group and independent grades for the same project.
- Encourage peer responses and have peers provide expert feedback in collaborative activities.
- Divide discussion boards, threaded discussions, and chats into small groups, making interactions more personal and not so wieldy.
- Monitor breakout sessions during synchronous discussions to help collaboration by facilitation.
- Engage students in paired work rather than in large group structures.

Future Research

Further research is needed to investigate students' perceptions of online communication, collaboration, and relationships in the class, which should be compared to faculty perceptions. In view of the fast developing social networking on campuses, it is necessary to determine if there is any correlation between the use of synchronous and social learning tools and learning outcomes in online courses. With the spread of communicative activities in online classes, further research is also wanted to determine if there is an improvement in technology-mediated academic discourse. Asynchronous tools, particularly threaded discussion, have proven to be most successful in sustaining academic discourse because of the delayed response time, which allows students to think, read the texts, construct, and properly format their posts. A healthy blend of synchronous and asynchronous communication activities might be the right solution, and this needs to be studied too. Finally, with the instructor's role remaining paramount to the quality of online communication and collaboration and, consequently, quality learning outcomes, professional development issues have to be carefully addressed. As one respondent noted, "facilitating online instruction is an art that involves a high degree of training." This calls for effective institutional professional development, as well as mentoring, modeling, and coaching for beginning instructors from the more experienced colleagues.

Conclusions

There was considerable concern among many faculty members that online students are indeed different from onsite students, and that some students tend to lose their social, civic, and humanistic traits and become distanced, solitary, impersonal, and unemotional in an online environment. University faculties generally realize that communication and collaboration among students and between students and their instructors are desirable: Fostering a highly interactive and collaborative online environment can enhance student learning. The majority of instructors in this study (85%) believed in the power of personal relationships in an online class and considered that they should develop them; many, however, were still unsure that online learning

promotes relationships and creates an environment that blends intellectual and formalized learning with social learning. This indicates that the loss of the ability to be social in an online environment may be noticed in the effect of student estrangement, which, they hoped, could be remediated through the use of social and collaborative tools. Faculty members agreed on the need to establish and maintain personal relationships among students and to integrate affective and emotional moments in their teaching. It was reported that many of them do indeed organize and facilitate teamwork in online classes and use a number of tools and strategies to accomplish this dynamic. At the same time, a number of faculty members were not maintaining collaboration and were not supporting the development of relationships for student interactions in online classes. This necessitates further research in this area, dissemination of the best practices, and effective professional development and institutional control.

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Appendix 1
Questionnaire

1. – 4. Demographic questions

5. Do you believe online learning is a social (group) activity?

6. Do you believe online learning is an independent activity that does not include an emphasis on group work?

7. In regards to your online classes, specifically what kinds of social/interactive activities do you and your students engage in?
   1) Threaded discussions for social purposes
   2) Threaded discussions for academic purposes
   3) Synchronous discussions using text chat
   4) Other synchronous tools (please specify the tools)

8. Do you believe online learning allows for collaboration and cooperation among students?

9. Do your students like to collaborate with class members in online classes? Why or why not?

10. What kinds of strategies do you use in your online classes to engage students in group work?

11. Regarding the social climate of your online classes, do you believe that relationships in the class affect the outcomes of student learning? Why?

12. How would you rate the social climate of your last online class?
    Very negative (1) through very positive (4)
    If there were negative social interactions, please briefly describe in the comments section.

13. Which of these elements are necessary for effective student collaboration in an online class?
    1) Face-to-face interaction (live in a physical space as opposed to web cam)
    2) Web cam presence
    3) Personal one-on-one contact with students via electronic tools (email, Skype, telephone, etc.), 4) Students' personal relationships with peers and instructor
    5) Empathy in interactions
    6) Confidence in the group partner(s)
    7) Desire to help and share
    8) Willingness to learn from others
    9) Trust established between partners
    10) Instructor's insistence to work in a collaborative relationship
    11) Instructor's personal teaching style
    12) Team work
    13) Other critical factor not listed (Please explain in comment box)

14. Do you believe that online learning promotes relationships in the class? Please explain your point of view in the comment box.

15. Do you believe online classes should be personalized in the way that students develop more personal relationships in the class with the peers and with the instructor? (Explain why you believe as you do in the comment box).

16. In your opinion, do we need to establish empathy, emotions, and personal relationships in an online class? Please explain your thoughts.

17. Select one statement which indicates your assessment of students' attitudes:
    1) Feel a moral obligation to the instructor (includes respect, civility, and other norms)
    2) Willing to expand communication above and beyond the course requirements
    3) Desire more personal communication with the instructor

18. Select one statement about online learning:
    1) More virtual than real
    2) More impersonal than personal
    3) More independent than collaborative
    4) More asocial than social
    5) More emotionless than emotionally charged

19. Are there differences between your online students and students in live (face-to-face) classrooms? Check one of the following:
    1) Online students are different from face-to-face students in live classrooms
    2) There is no difference between students in face-to-face students in live classrooms
    3) Students are the same

20. Do you believe students lose some civic, personal, humanistic traits and become estranged, distanced, impersonal and unemotional in an online class?

21. Two last demographic questions: In addition to using online tools through my institution or my learning management system (LMS, i.e. eCollege, Blackboard, etc.), do you also use the following social media tools in your classroom? Please check all that apply.

    Blogs, Wikis, Social Community Tools (Facebook, Linked-In, My eCoach, etc.), Online text-based chat, Voice-over IP Tools such as Skype, Photo Sharing (Flicker, Photo Bucket, Picassa, etc.), Twitter, Instagram, Other

22. In your opinion, what can we, college educators, do to help establish relationships among participants in an online class?

23. What kinds of teaching strategies and techniques can cause empathy and arouse affection in an online learning environment?

24. In your opinion, what needs to be done to develop empathy and collaborative personal atmosphere in an online class?

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Economics, Engagement and Deeper Learning: Game Design Methodology Approach

Nelson Altamirano

Abstract
Teaching microeconomics with games usually requires the instructor to create games and play them in the classroom. The author claims in the paper that this approach is too costly for the instructor and does not ensure deeper learning. A better alternative is the game design methodology approach; it reduces instructor's costs and increases the chance of students' getting deeper learning through the use of Excel-based teaching tools and group assignments that ask students to create their own games.

Key Words
Teaching economics, engagement, experiments, deeper learning, gaming, games

Introduction

Gaming is changing our approach to teaching and learning in business schools. It has been adopted intensively from K12 to higher education into STEM+ subjects because of its power to attract and engage students into these difficult fields (Lewis & Massingill, 2006). Many studies have shown that once games engage students, other positive effects occur, such as the ability to create meaningful learning environments, active learning participation, knowledge retention, and application of theories (Magerkurth, Cheok, Mandryk, & Nilsen, 2005; Billings & Halstead, 2005; Horsley, 2010). Although all these benefits are important, not all studies found deeper learning. What are the conditions to for students to get deeper learning when they are taught with games? How costly is for the instructor to convey deeper learning? Can we reduce those costs and increase the chance of deeper learning? I will discuss these questions in the next section and then present a new approach to gaming for economics, sharing some qualitative evidence and ending with conclusions.

Evaluating Playing Games in Economics

Learning Evaluation

The learning benefit that comes from playing games in the classroom depends on the type of game being played and the specific experience generated during the playing time. Games are virtual models with rules, incentives, payoffs, and player's strategies, some more complicated than others. For instance the double-auction market game is popular among economics professors because it is fun, flexible, and practically trouble-free (Bergstrom & Miller, 1997; Holt, 1999). Players are divided into buyers and sellers of a single product. Each player has "private" information others should not discover, and all players enter into the trading ring with the objective of maximizing their own benefit. Players get excited fast; it is really loud and chaotic, and some are confused in the first two rounds, like in real life. Instructors record all transactions and show the market price at each round. Players calculate their own benefit and instructors introduce external shocks into the game, such as taxes, subsidies, market boundaries, and more. Players create live data about market equilibrium without realizing they are the live agents of the demand and supply in the market. Playing the game alone is the most intense

experience of engagement any instructor can develop in the classroom, and students will never forget this experience.

Before discussing deeper learning at the double-auction market game, let me state that I understand deeper learning "as the process through which an individual becomes capable of taking what was learned in one situation and applying it to new situations" (Pellegrino & Hilton, 2012, p. 5). Through deeper learning, the individual gains expertise in a particular area of knowledge and is capable of knowing "how, why, and when to apply this knowledge to answer questions and solve problems" (Pellegrino & Hilton, 2012, p. 6). The deeper learning process usually requires interaction within a community of learning, and the result is the individual gain of both knowledge and skills appropriate for the 21st century.

The deeper learning at the double-auction market game occurs after the two winners, one for the sellers and one for the buyers, enjoy their prizes and the playing time is over. It comes at the debriefing section, where the data of demand and supply is released and players visualize exactly the location on the demand or supply they were at during the game. This visualization is very important, to go beyond the intangible representation of a market with two lines crossing each other. Lines become points with real names, and students recognize themselves inside the demand or supply. Downward and upward lines are no longer abstract because players are buyers or sellers inside those lines.

After this identification step, each buyer or seller can visualize its relative position in respect to the other buyers or sellers. It is intuitively clear for them that in order to win the game, for instance, it is much better to be in the lower section of the supply than in the upper section of it because offering a product at low individual costs is better than offering it at high costs. The potential profit would be higher, but the profit will depend on the real bargaining done with buyers, and not all buyers are identical. Some buyers are in the lower part of the demand, whereas others are in the upper part. The visualization of all this information empowers students to understand the behavior performed by some players during the game. More important, this visualization empowers them to predict who would be the most likely winners and apply the theoretical concepts to different situations of demand, supply, willingness to pay, willingness to sell, maximum price for buyers, minimum price for sellers, individual costs, and market price.

Other elements of deeper learning gained during the double-auction game are the understanding of market price of equilibrium, competitive markets and the "invisible hand" process that leads to market equilibrium. These key concepts were explained in words for the first time by Smith in 1776, and Marshall was the first economist to present Smith's ideas mathematically and graphically in 1890. Since then, all microeconomics textbooks follow Marshall's abstract and technical presentation rather than Smith's descriptive models. Although Marshall recommended using math only as a shorthand language and never as an engine of inquiry, its technical presentation of a market with two lines became the standard (Dimand, 2007). Teaching the market model with lines makes sense only when we undercover the real interaction of buyers and sellers. Without the uncovering, students learn lines, understand formulas and find equilibrium points and become technical experts by a process of repetitive exercises. However, most students cannot go beyond the idea of points and lines and seldom can apply those technicalities to real markets. The debriefing section of the second-auction market game empowers students to understand real markets and discover how beautiful it is to represent key real market features with two lines. In other words, the debriefing section makes students experience the deeper learning process that Marshall must have undergone in order to write his *Principles of Economics* in 1890.

Evaluating Costs

The costs of preparing, designing and customizing games for economics, including their respective debriefing sections, are high. These costs include not only the time professors spend to prepare games, but also the class time required for playing and debriefing. There are a limited number of sessions per term and a syllabus to cover with more topics than sessions, so the opportunity cost of playing games is that some topics are left out. The fact that regular lectures require less time to prepare and can maximize the number of topics covered per class makes it difficult for instructors to adopt a gaming approach, unless the net benefit of games is clearly positive.

The net benefit for the double-auction market model is positive when done properly because of the gain in deeper learning, but what about other games? Durham, McKinnon, and Schulman (2007) found, in a three-year study of experiments (games) for principles of microeconomics and macroeconomics, that experiments improve learning when dealing with abstract and difficult-to-understand concepts, but they deliver zero or even negative learning gains with less complex topics. When controlling for type of learners, kinesthetic and multimodal learners benefited the most with experiments, read-write learners performed just as well as in the traditional lecture/discussion format, and visual and aural learners benefited only in the macroeconomics sections. Based on these results, it can be concluded that economics professors interested in developing games must be very careful in selecting topics, and they should consider the learning types of their students or risk negative learning gains. In the Durham et al. (2007) study, for example, 71% of subjects were multimodal learners, 16% were kinesthetic learners, 7% were aural learners, 4% were read-and-write learners, and just 2% were visual learners.

If we consider (a) the high costs of creating games for professors of economics in the form of preparation time and opportunity costs of playing games in the classroom and (b) uncertainty of learning benefit because it depends on topic and student learning type, then it is understandable why the use of experiments are still the exception rather than the norm in the way economics is taught today.

Alternative Approach to Reduce Costs and Increase Deeper Learning

The alternative advocated in this paper does not require professors to design and play games in the classroom. Economics professors were not prepared in graduate schools to teach with games or consider the type of learners they would encounter in the classroom. Their learning curve is so steep that this could be enough to deter faculty from playing games in the classroom. Therefore, it is better to have a gaming learning approach that transfers the creation of games and the deeper learning experience directly to the students.

The game design methodology (GDM) minimizes some of the costs mentioned above and maximizes the gain of deeper learning. Professors do not have to design games directly and spend time preparing and playing games that may not engage students or produce no deeper learning effect. In this game-design environment, students build the games that demonstrate course learning outcomes and the often complex relationships of economics concepts. Students are moved into a creative arena, where they understand the forces that govern the relationships of their own games (Jaurez, Fu, Uhlig, & Viswanathan, 2010; Prensky, 2001).

The approach of asking students to develop their own games using economics concepts within the rules and strategies is not new to students or economics professors. This is the same approach science school teachers use when asking their students to develop control-variable

strategy experiments (Altamirano & Jaurez, 2013). It has been demonstrated in the literature that a combination of lecturing and hands-on experimentation gives better learning outcomes than lecturing alone or experimenting alone (Lorch et al., 2010; Rieber, 2005). The role of the instructor focuses on guiding and coaching for a game creation that effectively improves learning. This approach makes students focus on the hands-on aspect of experimentation.

The GDM approach works well with adult learners, the type of population at National University (NU), and most business schools. Adult learners are independent and self-directed, value life experience with age, want learning to be linked to required tasks, focus on problem-centered learning, and are primarily motivated by internal sources (Merriam & Caffarella, 1999). In addition, adult learners usually bring prior knowledge and experiences to the classroom. Asking students to create their own games makes them relate economics with real life experiences and prior knowledge; their learning becomes problem-centered rather than content-oriented, and students focus on the concepts they need to learn in order to develop their games (Altamirano & Jaurez, 2013; Knowles, Holton, & Swanson, 2005). GDM empowers students into deeper learning by exploiting their prior knowledge and learning style (independent, self-directed, problem-centered). GDM empowers faculty into the role of game facilitators rather than game creators. Empowering students to take charge of their own learning experience is the most positive way of having them embrace the learning process (Lim, 2008).

GDM for economics is a teaching and learning approach that focuses on the process of creating a game rather than the final output itself. The benefit of deeper learning occurs even if the final outcome is still perfectible in engine features and looks. It has been demonstrated that most learning occurs at the creative stage of games, where modeling, designing, and testing are the main drivers (Rieber, 2005; Prensky, 2008; Jaurez et al., 2010). Instructors should facilitate this creative stage rather than the end game itself. How the final product looks depends on (a) technical graphical capabilities that students already have, using Microsoft Office software, and (b) the minimum support that economics instructors can provide. Economics professors should focus on teaching economics and facilitating the application of key concepts to the game environment envisioned by students.

The creation of games by students is a collaborative effort that delivers important additional benefits highly valued in job markets. Most students of business schools are familiar with paper and homework assignments that are standard at the university level. However, few have been exposed to innovative, creative, and non-traditional assignments in the context of social sciences. Creative assignments are more common in arts and engineering schools than in business schools; GDM for economics forces students to move out from their comfort learning zone into a new learning arena that requires collaboration and working in groups. As a result, students improve teamwork, writing, presentation, and Excel skills in a self-driven environment boosted by the engagement of developing their own games. Students not only learn economics at deeper levels but also acquire job soft skills that will help them at their workplaces.

Game Design Methodology for Economics at National University

The specific application of GDM in this paper is for microeconomics at the undergraduate level. Principles of Microeconomics (ECO203) is taught in 4 weeks at NU, and it is a core course for general education and the Bachelors of Business Administration at the School of Business and Management. NU is a non-traditional university for working adults who are attracted to its one-month format. Students and instructors focus exclusively on one class per month, and the same

content offered by traditional universities that follow a quarter or semester format is delivered in 4 weeks and 45 hours of instruction time.

The challenge of the one-month format is not so much on the length of the term to cover content but on the time necessary to digest and assimilate new knowledge. The length of the term per course at NU is 4 weeks, while full-time students of quarter-based universities have only 3.3 weeks per course. Under the one -month format, students focus only on one class; and when it is done, they move to the next. Under the quarter format, students take three courses simultaneously. A full time undergraduate student in a quarter system takes 3 courses (12 units) in 10 weeks, or 3.3 weeks per class. NU offers the same class in 4 weeks, and students focus on only one topic during the month instead of three.

Students in both formats have fast and intense learning environments, and they must administer their time effectively. It seems the one-month format fits well with adult working students who cannot stop working but want to advance in their professional careers. The real challenge is to ensure that students can digest and assimilate the flow of new knowledge they are exposed literally every day. Exams become tools for helping students digest and synthesize knowledge, rather than functioning as pure testing instruments based on memorization. Lectures should incorporate delivery methods that speed comprehension and critical thinking.

The basic learning model for microeconomics at NU is to create weekly modules with course learning outcomes, teaching content, learning activities, and proper assessment. Students learn the basics of economics and markets during week 1, supply and demand applications in week 2, type of markets during week 3, and finally resource markets and the role of governments in week 4. A significant assessment item occurs at the end of every week, and the game assignment we introduce in this course does not alter this basic structure. Of the three exams, exam 1 covers the material of week 1; exam 2 covers the material of week 2, and exam 3 covers the material of weeks 3 and 4. The game assignment replaces the course paper due by the end of week 3, as seen in Table 1.

Table 1. *Game Assignment and Course Grading Items*

Activities and Assignments	Grade
Live session attendance	8%
Weekly discussion	8%
Group game assignment	20%
Group presentation (individual grade)	5%
Exam 1	18%
Exam 2	18%
Exam 3 and learning outcomes	23%
Total	100%
Extra credit: Comment game description	2%

Given the intensity of the NU term, exams are tools for learning rather than tools for testing, so questions assume an environment of open books and this is the time for students to consolidate and integrate knowledge. The group assignment itself counts for 20% of the course grade, and two related activities add 7% more: A presentation of the game assignment in week 4 (5%) and a comment on the game description presented by other groups in week 2 as extra credit (2%).

The group game assignment is a complex task that demands the delivery of a paper in Microsoft Word, an engine in Excel, and a presentation in PowerPoint. The paper has the format of an academic paper with a slightly changed structure: It has an abstract and introduction with the motivation, logic and relevance of the game idea; then it has two sections to describe the game (rules, players' objectives and strategies, moves, and payoffs) and explain the game engine. Next is the most important part of the paper, the debriefing section, where groups explain the economics concepts introduced in the game, the logic of the winning strategy, and the prediction of what actions, decisions, or strategies determine the winner of this specific game. Finally, the paper contains a reference list and attachments with relevant screenshots of the engine.

The engine is a workbook in Excel that contains different interconnected sheets with the game board, data, formulas, and graphs, as well as calculations of all payoffs that correspond to all decisions players make. The author has observed that most groups choose to create Monopoly-like game boards where players roll a die and land in a cell that contains some instructions for the player. Some go with Jeopardy-style game boards, and few create boards that recreate the physical environment of their games, such as a lake for a fishing game. The rest of the engine depends on the nature of the game groups want to create, i.e., demand or supply oriented. If the game is about consumers who will buy items to maximize satisfaction, the formulas, graphs and all calculations will be adaptations of consumer, demand, and market theories. If the game is about sellers who want to maximize profit, the engine will contain adaptations of production, cost, and market theories.

The engine is the result of a hands-on learning process that starts with the instructor's teaching properly, the group's creating a game idea, and the group's closing the circle with the operationalization of that idea with microeconomics concepts, formulas, and calculations.

The teaching of microeconomics for GDM requires the instructor to use Excel based tools for main concepts that are key to the week's course learning outcomes. The concepts selected for our 1-month format are standard for any Principles of Microeconomics class (Table 2), and all have great potential to be used in game simulations. These tools are Excel based with macros and free add-ins, have formulas with algebra and no calculus, present a real story that captures the attention of students, and use real data rather than imaginary data creation. Teaching becomes visual, dynamic, intuitive, and ready for interactive learning.

To illustrate the differences between Excel-based tools and traditional tools to teach principles of economics, consider the concepts of demand, shifts of demand, and movements along the demand curve. The traditional professor would illustrate the demand with an ad-hoc downward sloping line and mention that price and quantity are inversely related, as seen in Figure 1. The professor would say that demand depends on the price, price of complements, price of substitutes, income, and preferences. When price changes, the professor would signal a move on the line and say it is a change in quantity demanded, but when income or any of the other variables change, the professor would say the line shifts to the right or to the left, reflecting

a shift of demand. Figure 1 shows a shift to the right that may correspond to an increase in income.

Table 2. *Microeconomics Concepts with Excel Tools per Week*

Week	Concept
1	Demand and supply; market equilibrium; opportunity cost
2	Consumption decisions; production decisions
3	Competitive markets; monopoly markets
4	Government intervention

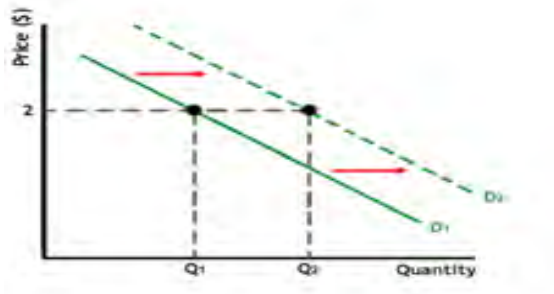

Figure 1. Demand shifts in traditional texts.

The Excel-based tool for demand visualizes a real demand for ground beef for a family of four who wants to make hamburgers, as illustrated in Figure 2. This demand tool is a customized version of Barreto's Introductory Economics Labs, *Lab 1: Supply and Demand* (Barreto & Widdows, 2012). It contains a story on the top, step-by-step instructions on the left, a section with values for the price of ground beef, prices for hamburger buns, ketchup, and hot dogs, and values for income and tastes. It also has in the lower part a dynamic graph with a line and a table with the points that make up the line. The graph changes as the instructor and students change the price of ground beef or price of hot dogs or income. The instructor does not need to explain abstract concepts because students intuitively identify that hot dogs, for instance, are substitutes of hamburgers; and when they change the price of hot dogs, they see in front of their eyes the shift effect on demand. After playing and repeating the changes of the price of hot dogs, students end up explaining the logic behind those changes and are able to generalize from hot dogs to substitutes. They also can learn about inferior goods when income increases above $50,000 per year for this family and end up with a clear idea of what the model of demand is about. This specific tool demystifies the abstract character of economic theory; it is visually accurate, intuitive, and interactive, and it leads to deeper learning. Furthermore, it introduces students into data analytics with graphs that come from tables that use real data, and formulas based on math and statistics learned previously.

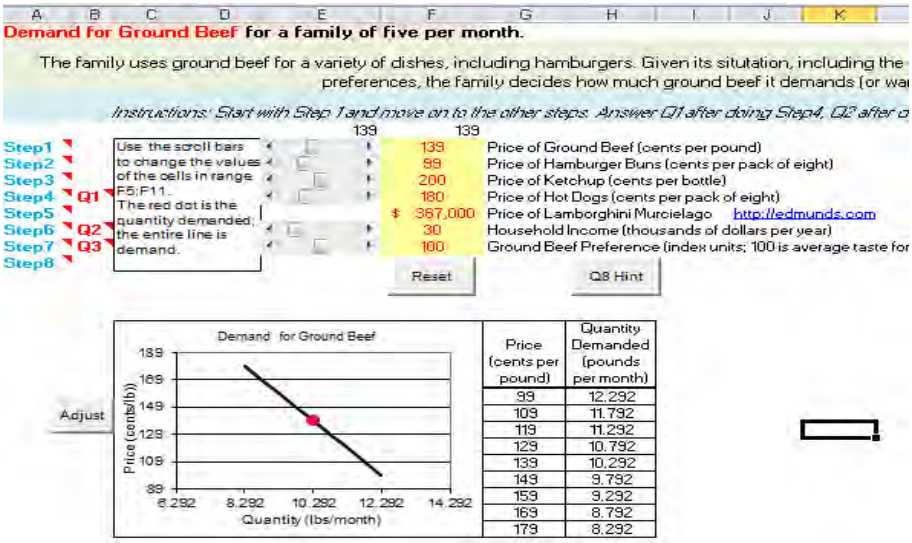

Figure 2. GDM tool for demand in Microsoft Excel.

The introduction of Excel teaching tools makes instructors focus on the teaching of economics and allows students to discover for themselves the logic behind key economic theories and models. All tools developed for ECO203 combine data with dynamic graphs and require the user to actively change key values, see the effects on graphs, and explain those changes. There are complementary exercises in threaded discussions that require students to use these tools. The more students play with these instruments, the more they learn that economics is about models. Each tool is just a representation of a specific economic model in Excel, and students become familiar with external and internal variables, as well as causation. Cost functions, for instance, are presented for any fixed cost possible, and demand functions change depending on the slope or intercept values. More important, Excel facilitates, almost instantaneously, the creation of different scenarios or family of problems. This is extremely helpful to discuss elasticity, opportunity cost, or prisoner's-dilemma models. The tools are for students to reverse engineer and discover the nuts and bolts behind each cell. Behind cells and numbers are formulas that incorporate economics and Excel language. Students learn both economics and Excel at high levels.

Deeper learning, as defined earlier, is about "applying," rather than just "using." Deeper learning comes when students apply and customize some of these tools to their own game simulations. This step requires instructors to facilitate the transition from their game idea to the game engine. The role of the instructor is similar to the role instructors assume when students propose to write papers that are "too general" or "too big." Instructors, teaching with GDM tools, would suggest that students get simple and more concrete, identify the key concepts they may use, and review the respective Excel tools with the perspective of how to modify them in order to make the tools part of their game engines.

Based on the author's experience at NU, groups have no problem finding good game topics. Working adults have many real-life experiences they want to incorporate into their games, and it was found very useful to motivate student-to-student review of ideas at the initial stage of the process with an extra-credit incentive. The challenge for students is to connect the game idea with concepts and formulas that are part of the game engine. Instructors need to offer live office

hours, simplify game concepts to something that can be made operational with the tools used in class, show how to reverse-engineer some key components of those tools, and make these advising sessions available to all students. Transparency and availability of information through the entire process of game creation ensures the success of GDM.

Student Created Games and Deeper Learning Results

The aforementioned GDM tools, along with the game assignment, were tried during the 2013–2014 academic year. A total of 180 students in groups of three to five individuals created more than 30 games. Names of games created in the last two sections were Bakery Madness, Economic Battleship, Econ-O Trivia Game, Jeoparnomics, Retire Quick!, Supermarket Dash, The Tycoon Industrialist Game, The Fishing Game, The MRI Clinic Administrator Game, Learn and Lead Pizzeria Trivia Game, and Color Me Economics. These titles reflect well the creativity side of this type of assignment. Students get engaged with it, and perhaps for the first time in a STEM+ course they are asked to think out of the box, be creative, and explore venues they may not feel comfortable with. The game assignment is fun, and fun is not precisely something students are normally asked to experience in academic assignments. The assignment requires artistic and technical skills that students have accumulated before but have never been asked to use in academic settings. All students feel the pressure of doing something they were never asked before, do not comprehend entirely during the first week of the term, but accept to do it. Yet, after the first week, all students are completely engaged into it and happy to release their creativity skills.

The first sign of higher learning comes from the type of general questions students pose after class and during office hours: How can I do this? How can I show this? How can I explain this? All these questions are related to economics concepts and Excel formulas that may had been introduced in class but now require further treatment just for the students requesting it. The games they develop can be categorized as demand or supply driven. Demand games focus on buying choices, given a budget and a maximization goal that may be satisfaction or wealth. Supply games focus on selling or producing choices, given a restriction and a maximization goal that may be profit or revenue. External shocks change initial conditions, and these shocks are usually related to opportunity costs, implicit costs, fixed costs, government regulation, and new market conditions. In most games developed by students, players can start guessing their moves but usually end up thinking on economic theory to make their best decision. Therefore, students are interested in learning more about economics and Excel in order to develop their games, and this self-motivation is powerful enough for them to invest extra effort.

Game boards fit within one of three types. Most games present rectangular Monopoly-like boards with cells around a central area, and players should move clockwise from start to finish. Others have trivia game boards like Jeopardy-TV games, and a few have boards that reflect the specific environment of the game, like the screens of a video game. The game board is the Excel sheet that players of the game will see and make decisions from; players will not see the engine itself. The game engine runs in the back of the game board through macros; in other words, cells in the game board are linked to other cells in other Excel sheets that make the appropriate calculations based on formulas that reflect economic concepts. The result is that the game engine and the game board are basically the model students want to represent and visualize. The sophistication of calculations, as well as the refinement and complexity of the model, depends on the effort students invest and their previous background.

Trivia games have the simplest engine, Monopoly-like games have a bit more elaborate engines, and games with customized game boards have very complex engines that reflect deeper learning. Trivia games are basically Q&A games, with students' designing questions by degree of difficulty and presenting solutions; these games use economics concepts and show that students understand those well, as they take advantage of Excel to create a family of questions with multiple options and nice visualizations. Monopoly-like games combine Q&A with some objective players have to achieve at the end of the game; they use economics concepts and apply those concepts to situations that are still independent. Games with customized game boards use and apply economics concepts to an entire model, in which players make decisions within a simplified world represented by economics rules. The following section presents an example.

Student Game Example: Fishing Game

The idea for this game came from a student who loves to fish, who was familiar with fishing tournaments, and who convinced his group to focus on a game where each player will represent a fisherman. Players would compete against each other to catch the most fish and sell the fish to the market, and the winner would be the fisherman with the highest profit; so the general idea was to apply concepts of production, costs, revenue, and markets into this smart game idea. Of course, the challenge for this group, and for any undergraduate student, was to go from concepts to functions to data and to "realistic" calculations in an environment that integrates more than one concept, and it is called the game engine. The game board is in Figure 3.

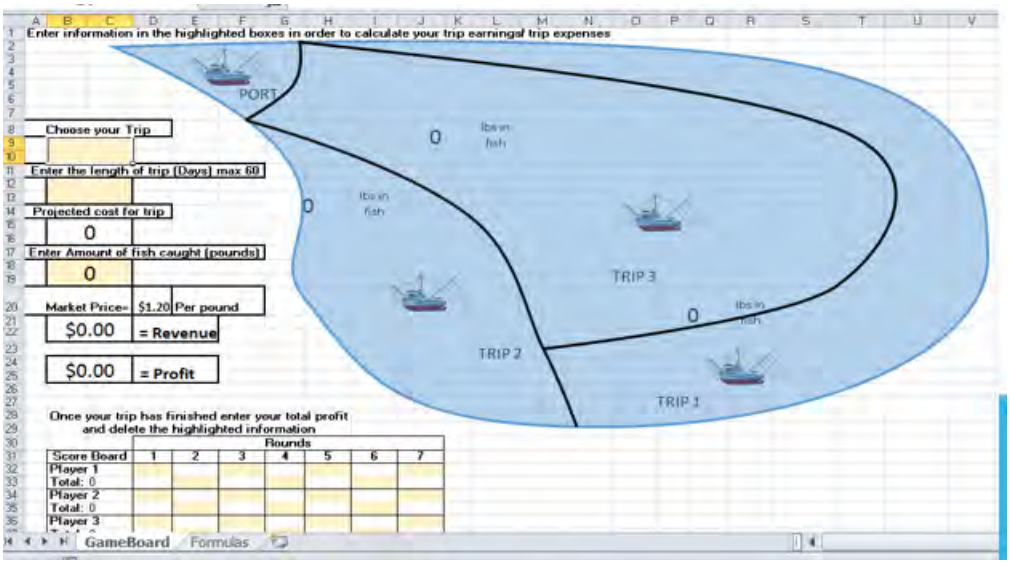

Figure 3. Game board of Fishing Game.

The main idea for the game was to have players who would make fishing trips using different types of boats and fish on different parts of a lake. Fishing boats have different equipment on them, and lakes have areas that are preferred over others because of their relative probability of finding fish there. The theoretical connection to economics became clear when the author

explained in more detail to the group the Cobb-Douglass production function used in the Production Decisions Excel tool ($Q = AK^bL^{(1-b)}$). The deeper learning occurred when the group customized this function to their game characteristics: the amount of fish caught (Q) depends on the area of the lake (A), the type of boat (K), and the time of fishing (L). The group decided that players would receive their boats and lake areas randomly but would decide the length of their trip. In other words, A and K would be given and L would be the decision variable. The group created three production functions for three different fishing trips.

The costs of fishing trips include fixed and variable costs. Group members discussed the items that would fit in each category, made the connection with the K and L of the production function, and used the Excel-based tool presented in class for production and cost functions, including the concept of opportunity cost of time for each fisherman.

Revenue calculations need a price market and the group wanted to model a fish market with supply and demand that responds to some shocks, so the price at the end of each round is not the same. To simplify the game engine, the group accepted the idea of a perfect competitive market where the fishermen playing the game are very small in respect to the market, and the price does not depend on the amount of fish brought by these players. The price was determined in the market, and players just accepted the price to calculate their revenue. However, the market price would vary, depending on external shocks created during the game.

The fishing game idea is simple, but the elements incorporated into the game engine are more appropriate for a graduate-level course than for a course of Principles of Microeconomics. The author's role as instructor was to teach economics in an interactive manner with GDM Excel tools, to introduce basic concepts, and to motivate students to explore new situations with those tools. Students became interested in production, costs, and market issues that were not part of the regular curriculum; they wanted to learn these in order to create their own game. They used office hours and worked hard to complete the assignment in week 3. Self-motivation is very powerful.

Conclusion

The three questions proposed in this paper related to what conditions are required for students to gain deeper learning when teaching with games, how costly these conditions may be to achieve this deeper learning, and how instructors can reduce those costs and increase the chance of deeper learning.

Playing a game may be the most intense experience of engagement any instructor can develop in the classroom, but it may fail too because, as is shown in the literature, some topics fail with games and some learning types do not benefit from playing games. In addition, the deeper learning occurs at the time of the debriefing rather than at the time of playing games. As a result, the costs of creating and playing games are high, professors of economics are not prepared to recognize learning types, and the benefits of deeper learning are uncertain.

The alternative approach presented within this article is based on making instructors of economics focus on teaching economics and transferring the creation of games directly to students. This approach reduces the costs for instructors because they do not create games that may be boring for students and will not take time to play games. Instructors instead will focus on teaching economics with Excel-based tools. These tools are dynamic and scientific, and they demystify the abstract nature of economic theories. Students, on the other hand, learn economics

by doing, and by working in groups to create their own games. The deeper learning occurs at the creation of game environments with rules and procedures that apply to economics.

This new approach is rewarding for both students and instructor, and it creates a learning environment supported by students rather than by instructors. There are always students during office hours with deep and interesting questions. Students invest so much time and effort on this project that instructors have to remind them about exams and other grading items too. The author encourages other instructors to try this in their own classrooms.

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Language Education

Adopting a New Identity: A Technique to Improve Writing Skill

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Abstract
This study aimed to investigate whether adopting a new identity could impact the writing ability of Iranian EFL learners. Sixty intermediate-level adolescent learners in two intact classes participated in the study. The experimental group selected a character from the target culture and developed it through chain-like episodes during a writing course, while the control group practiced writing through the techniques used in the process approach to writing. The results of the independent samples *t*-test and repeated measures ANOVA showed that the experimental group outperformed the control group. The interviews after the treatment signified a positive attitude toward the technique.

Key Words
Chain-like episodes, new identity, writing ability, culture, thinking, Suggestopedia, creativity

Introduction

Writing, as the process of several complex cognitive tasks (Bereiter, Burtis, & Scardamalia, 1988), is the most difficult language skill to master (Fischer et al., 2007). As Harmer (2006) argued, writing "leads to learning" (p. 31), "reinforces language use" (p. 32), and provides learners with "the opportunity to think about the language rules" (p. 33) and "receive precise feedback" (p. 34). A major goal of language teaching, thus, is to seek techniques and strategies which can support EFL/ESL learners to become skillful writers.

Writing is defined as a thinking activity (Kurfiss, 1983; Lipman, 1980; Paul & Elder, 2003) and a "logical responsibility" consisting of a "series of conceptual decisions" (Lipman, 1980, p. i). Improving thinking skills helps learners be purposeful and write with a specific objective in mind (Paul & Elder, 2003). Accordingly, seeking for innovative techniques to foster learners' thinking and writing is of primary importance to researchers, educators, and practitioners.

However, learners' native culture impacts their thinking (Paul & Elder, 2003), as well as their "linguistic choices" (Hyland, 2009, p. 54). Culture limits thinking and the way individuals perceive the world (Paul, 2007). Therefore, teaching writing is linked to knowledge about the culture of the target language since, when learners write, they try to communicate "their knowledge and beliefs about the world" (Lantolf, 1999, as cited in Hyland, 2009, p. 54). A solution is to help student writers go beyond cultures in order to think differently (Paul, 2007). Techniques used in writing classes should provide learners with the opportunity to penetrate the minds of the target language speakers and experience how they look at the world.

Studies on contrastive rhetoric suggest that ESL students' writing is affected by their first language and the cultural values they reflect (Connor, 1996; Connor, Nagelhout, & Rozycki, 2008; Kaplan, 1966). Thus, non-native learners' writings may differ from those of the English students. This fact implies the decisive role of knowledge about the cultural aspects of the target language in teaching writing. As Connor (1996, p. 5) argued, "language and writing are cultural phenomena," and each language has "rhetorical conventions unique to it."

Background of the Study

Writing is a "dynamic and creative process" (Usó-Juan, Martínez-Flor, & Palmer-Silveira, 2006) and needs to be taught through attractive activities that are relevant for the learners (Harmer, 2004). The writing tasks, as Harmer believed, should motivate learners, engage them intellectually and emotionally, and help them have a positive attitude toward writing. In the same vein, Lipman, who argued for the writer's logical responsibility, asserted that writing activities must stimulate thinking and provide learners with a purpose to write while suggesting indirect ways such as poetry and law (Lipman, 1980). Harmer also believed that any activity that can evoke ideas and provide a pattern to follow can be beneficial in writing classes and suggested the use of pictures, music, and swapping papers to encourage creativity in writing. Producing biographies of people who interest learners is also recommended as a writing activity to enable student writers to synthesize "genre and process approach" (Harmer, 2004, p. 96). Similarly, Williams (2003) proposed simulations as stimulating activities that provide students with "reason to move out of their role of student and into the role of writer" (p. 125).

In the present researchers' quest for a technique to help EFL students write creatively with the "rhetorical stance similar to those of native speakers" (Williams, 2003), Harmer's biography writing and Williams' role-play activities seemed appealing. Also, in order to involve students in continuous writing, the researchers decided on episodic writing through which students could have the opportunity to imagine themselves in various real-life situations. This idea resembled *adopting a new identity* proposed by Lozanov in the *Suggestopedia* method of language teaching. New identity as a "cute device on the cognitive level" (Stevick, 1983, p. 118) is believed to help learners see themselves in the foreign culture, and detach themselves from the "norms and limitations" (Stevick, 1983, p. 116) their own society has dictated to them. It can bring "positive and pleasant associations" and help learners take roles not by their "real Self" but by their "surrogate Self" (p. 118). It was presumed by the present researchers that the imaginary identity would help learners engage in learning and use the rhetorical norms of the target language; the expectation was that involving the learners in chain-like stories and looking at social situations from an imaginary individual's viewpoint might help them "enter the minds of others" (Paul & Elder, 2003, p. 5) and write from a native speaker's position. Additionally, it was assumed that taking part in imaginary social situations would be a good practice for language learners to organize thoughts and engage in creative thinking and writing.

Although Scovel (1979) argued against *Suggestopedia* and considered it a "pseudoscience," he agreed that the method can be the "source of useful teaching techniques" (p. 91). The philosophy behind *fictitious identities* in Suggestopedia is to help learners forget social barriers of the real life; what Lozanov called de-suggestion (Richards & Rodgers 1990). The process of desuggestion, or "unloading the memory banks [of] unwanted memories," and suggestion, or "loading memory banks [with] desired memories" (Richards & Rodgers, 1990, p. 145), is facilitated when students adopt new identities. Moreover, the "new name and personal history within the target culture" enable students to participate in classroom activities (p. 149).

The purpose of the present study, however, was to help learners experience thinking differently, to stimulate ideas, and to provide a story map to encourage learning the cultural values and rhetorical conventions specific to the English language. The researchers were curious to find out whether adopting new identities could help learners actively engage in writing. The technique was used regardless of what *Suggestopedia* advocated about de-suggestion and

suggestion in Soviet psychology. Hence, the aim was to investigate the following research questions:

RQ1: What is the impact of adopting new identities on the writing ability of Iranian EFL learners?

RQ2: Is there a significant difference among the writing achievements of those Iranian EFL learners who practice writing through new identity technique and those who use common writing techniques?

RQ3: What is the students' attitude toward adopting a new identity in writing classes?

Method

Participants

The participants included 60 Iranian intermediate level adolescent learners between 12 and 18 years of age who were selected based on convenience sampling from a language school in Tehran, Iran. The two intact classes were randomly assigned to an experimental (19 girls and 11 boys) and a control group (17 girls and 13 boys). The classes were held 16 sessions within a semester and met twice a week at a 90-minute duration.

Instrumentation

The first research instrument was a writing pretest, "Write about your parents." The eight topics selected for writing during the treatment comprised the next instrument of the study. Learners in both groups wrote five-paragraph compositions on the selected topics. It took two sessions to complete each composition. A writing posttest, "Describe a memorable moment in your life," examined the learners' improvement after the treatment. Also, a set of interview questions were prepared to ask the members of the experimental group about their attitude towards the technique

Procedure

Pretest. The pretest showed that the groups were equivalent in terms of their writing ability at the onset of the study. The compositions were scored by two experienced raters using Jacobs, Zinkgraf, Wormuth, Hartfield, and Hughey's (1981) ESL Composition profile. The inter-rater reliability reflected a high correlation between the two ratings ($r = .92$). Each participant's writing pretest score was the mean of the two sets of scores. The pretest revealed no significant difference between the groups in terms of their writing ability.

Experimental group. During the first session, the purpose of the new identity technique was clarified. Some (mostly boys) questioned it and were reluctant to choose new identities. Thus, the teacher divided the class into two groups of those who were in favor, and those who were against the technique and wanted them to conduct a group discussion while answering the following questions:

- Why should/should not we adopt new identities? Give your reasons.
- Is it possible to adopt an imaginary identity?
- What are the negative and positive points regarding adopting a new identity?

During the class discussion, those learners who were against the new technique asserted, "I am happy with my real character; I am not interested in being in others' place; there is nothing

wrong with my real character; I am my own hero; I feel no need to have a new life style." Those who appreciated the technique stated, "it will give a kind of motivation and excitement to write; I find it attractive to write from a new person's viewpoint; it is like an interesting game; writing becomes a pleasant activity, it prevents writing from being a tedious task in the classroom; I can talk about what I cannot easily say in the reality; I feel I am a native speaker who writes about different topics in different situations." After the discussion, those who were against the technique agreed to cooperate.

Teaching writing followed the three stages of modeling, negotiating, and construction proposed by Hyland (2002, as cited in Usó-Juan et al., 2006). Each session began with the teacher's explanations about the mechanics of the writing skill; moreover, she provided some sentence starters, words, phrases, and idiomatic expressions appropriate for the topic of the day. The purpose was to cultivate the use native-like expressions in writing compositions. As the next step, the students talked about the related questions written on the board while their classmates were free to ask for clarification. For example, some of the questions related to the second topic '*Write about your job and a colleague with whom you work*' included:

- Where do you work?
- What are some of your responsibilities at work?
- How many people do you work with?
- How does your place of work look like?
- What is your salary?
- Do you like your job?
- What is the name of your colleague?
- How does s/he look like?

The teacher managed the time in order to give every student a chance to answer the questions. Typically, the learners made some funny remarks about the topics. However, the teacher was quite capable of directing the class according to the lesson plans she had prepared carefully. After the discussion, the participants started writing. They had the opportunity to complete the compositions at home and submit the subsequent session. The purpose was to develop a character and create chain-like stories in eight episodes. Students were supposed to check the Internet (e.g., www.biography.com) or different English textbooks (e.g. *Top Notch series* by Saslow, & Ascher, 2006) in order to create and adapt their imaginary characters as close to native-like characters as possible. The teacher controlled the students' writings for consistency in following the same imaginary characters they had selected. All compositions were corrected and returned to the students.

Control group. The participants in this group wrote on similar topics as the experimental group. Hyland's (2002, as cited in Usó-Juan et al., 2006) three-stage model was utilized in this group, as well. The participants also used outlining, clustering, listing, and drafting in the process of writing their compositions. These techniques were explained for them during the first session. In each session, during the pre-writing phase, the teacher led a brainstorm on the topic, and the learners were free to take notes. The teacher also wrote on the board some sentence starters, words, phrases, and idiomatic expressions related to the topic. Afterwards, the participants prepared an outline and exchanged ideas about their compositions. Volunteers wrote their outlines on the board for class discussion before beginning to write their composition. The learners worked on their drafts at home and submitted their compositions in the following

session. As a post-writing activity, the learners revised their compositions based on the teacher's feedback. Table 1 shows the writing topics used in the groups.

Table 1. *Writing Topics, Experimental and Control Groups*

Session	Topic
Two	Choose a new identity. Write about your new self (age, education, job, and family). (Experimental group) Write about yourself and your family. (Control group)
Four	Write about your job. Describe your room and a colleague with whom you work. (experimental group) What would you like to be in the future? Give reasons. (Control group)
Six	Describe the place (flat, apartment, or house) you live in.
Eight	Write about your hobbies.
Ten	Describe a memorable day in your life.
Twelve	Write about the city you live in. (Experimental group) Write about your hometown. (Control group)
Fourteen	Explain a day when everything went right (or wrong) in your life.
Sixteen	Describe yourself in the next 10 years.

Results

The descriptive statistics for the pretest are shown in Table 2. The skewness analysis indicates that the assumption of normality is observed in the distribution of the scores (–0.154 for the experimental group and –0.40 for the control group, both indices falling within the range of ±1.96).

Table 2. *Descriptive Statistics, Writing Pretest*

Groups	*n*	Mean	Standard Deviation	Standard Error Mean	Skewness
Experimental	30	1.575	0.342	0.624	–0.154
Control	30	1.658	0.331	0.605	–0.40

To ensure the two groups were homogeneous with respect to their writing ability prior to receiving the treatments, the mean scores and variances on the writing pretest were compared. As Table 3 indicates, the Levene's test ($F = 0.212$, $p = 0.647 > 0.05$) signifies the equality of

variances, and the t observed ($t = 0.958$, $df = 58$, $p = 0.342 > 0.05$) shows no significant difference between the means of the groups on the writing pretest.

Table 3. *Independent Samples* t-*Test, Writing Pretest*

	Leven`s Test		*t*-test for Equality of Means				
	F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean Difference	Standard Error Difference
Equal variances assumed	0.212	0.647	–0.958	58	0.342	–0.08333	0.8696

Using Jacobs et al. (1981) ESL composition profile, the compositions on the posttest were scored by the two raters. The inter-rater reliability indicated a high reliability index ($r = 0.91$). The means of the groups indicate an increase after the treatment; see Table 4.

Table 4. *Descriptive Statistics, Writing Posttest*

Groups	*n*	Mean	Standard Deviation	Standard Error Mean	Skewness
Experimental	30	3.85	0.213	0.039	–0.908
Control	30	2.68	0.293	0.053	–0.677

Table 5 shows the results obtained from the comparison of the mean values on the writing posttest. The Leven's test shows that the equality of variances was assumed ($F = 2.035$, $p = 0.159 > 0.05$), and thus running an independent samples *t*-test was legitimized. The comparison of the mean scores ($t = 17.61$, $df = 58$, $p = .000 < 0.05$) signified a statistically significant difference between the two groups, implying that the experimental group outperformed the control group on the posttest.

Also, to determine the groups' level of improvement, the eight compositions on the given topics were rated by the two raters. The inter-rater reliability showed a high positive correlation between the two scorings rr ($rr' = 0.91$). Thus, the mean of the two sets of scores for each composition was considered as each participant's final score. A one-way repeated measures ANOVA was run to compare the groups' scores from the first to the eighth composition.

Table 5. *Independent Samples* t-*Test, Writing Posttest*

	Leven`s Test		*t*-test for Equality of Means				
	F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean Difference	Standard Error Difference
Equal variances assumed	2.035	0.159	17.614	58	0.000	1.166	0.066

As Table 6 indicates, there is a significant difference between the writings of the groups. Therefore, it could be deduced that adopting new identities (independent variable) caused the difference between the writings (dependent variable) of the groups. To restate, adopting a new identity positively affected the participants' writing skill.

Table 6. *Descriptive Statistics, Writing Compositions*

Groups		Mean	Std. Dev.	*n*
Composition 1	Experimental	2.7000	0.55086	30
	Control	2.1000	0.44334	30
	Total	2.4000	0.58077	
Composition 2	Experimental	2.8417	0.64153	30
	Control	2.2000	0.46144	30
	Total	2.5208	0.64159	
Composition 3	Experimental	2.9583	0.65352	30
	Control	2.2083	0.43093	30
	Total	2.5833	0.66649	
Composition 4	Experimental	3.1167	0.57884	30
	Control	2.3333	0.42717	30
	Total	2.7250	0.64061	
Composition 5	Experimental	3.2583	0.48460	30
	Control	2.3417	0.46183	30
	Total	2.8000	0.65871	
Composition 6	Experimental	3.4383	0.42277	30
	Control	2.5750	0.34833	30
	Total	3.0067	0.58051	
Composition 7	Experimental	3.6000	0.40258	30
	Control	2.6167	0.43417	30
	Total	3.1083	0.64664	
Composition 8	Experimental	3.7083	0.39437	30

Control	2.4833	0.44496	30
Total	3.0958	0.74517	

Table 7 shows the equality test of covariance matrices. The test results indicate that the value of Box's *M* equals 79.18, $F(36, 11) = 1.87$, $p < 0.05$. Accordingly, the appropriate test to investigate the factors' effect in groups is Wilks' Lambda.

Table 7. *Test of Equality of Covariance Matrices*

Box`s *M*	79. 186
F	1.874
df 1	36
df 2	11319.368
Sig.	0.001

As Table 8 illustrates, Wilks' Lambda is 0.22, $F(7, 52) = 24.95$, $p < 0.0005$, and multivariate partial eta squared is equal to 0.77, enabling the researchers to conclude that there is a significant effect for time. This suggests that there is a change in the writing scores of the two groups across the eight compositions with the *large* effect size of 0.77, which accounts for 77% of the overall variance.

Table 8. *Multivariate Tests*

Effect	Value	*F*	Hypothesis *df*	Error *df*	Sig.	Partial Eta Squared
Factor 1						
Pillai's Trace	0.771	24.953a	7.000	52.000	.000	.77
Wilks' Lambda	0.229	24.953a	7.000	52.000	.000	.771
Hotelling's Trace	3.359	24.953a	7.000	52.000	.000	.771
Roy's Largest Root	3.359	24.953a	7.000	52.000	.000	.771
Factor 1 Groups						
Pillai's Trace	.398	4.917a	7.000	52.000	.000	.398
Wilks' Lambda	.602	4.917a	7.000	52.000	.000	.398
Hotelling's Trace	.662	4.917a	7.000	52.000	.000	.398
Roy's Largest Root	.662	4.917a	7.000	52.000	.000	.398

Note: Factor 1 refers to the within-subject variation; Factor 1 Groups refers to within-groups variation.

Since Mauchly's test (Table 9) was significant (0.001 < 0.05), the assumption of sphericity was violated. Thus, Greenhouse-Geissar was selected to compensate for the sphericity (0.71 > 0.05). The results of the within-subjects effects, as shown in Table 10, indicate that the type of treatment had a significant impact on improving the students' writing ability; $F(4.99, 4.99) = 39.1$, $p < 0.05$). Additionally, the type of the treatment was important and brought about a significant difference between the groups; $F(4.99, 4.99) = 5.40$, $p < 0.05$. Nevertheless, to examine which of the pair-wise comparisons were significant, Scheffe's test was run. As illustrated in Table 11, the pairs of the mean values show a significant difference in diverse observations.

Table 9. *Mauchly's Test of Sphericity*

Within-subjects effects	Mauchly's *W*	Approx. Chi square	*df*	Sig.	Epsillon *a*		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Factor 1	0.245	78.016	27	.000	0.713	0.802	0.143

Table 10. *Within-Subject Effect Tests*

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Factor1						
Sphericity Assumed	30.756	7.000	4.394	39.105	0.000	0.403
Greenhouse-Geisser	30.756	4.992	6.161	39.105	0.000	0.403
Huynh-Feldt	30.756	5.613	5.480	39.105	0.000	0.403
Lower-bound	30.756	1.000	30.756	39.105	0.000	0.403
Factor1 Groups						
Sphericity assumed	4.248	7.000	0.607	5.401	0.000	0.085
Greenhouse-Geisser	4.248	4.992	0.851	5.401	0.000	0.085
Huynh-Feldt	4.248	5.613	0.757	5.401	0.000	0.085
Lower-bound	4.248	1.000	4.248	5.401	0.000	0.085
Error (Factor1)						
Sphericity assumed	45.617	406.000	0.112			
Greenhouse-Geisser	45.617	289.538	0.158			
Huynh-Feldt	45.617	325.541	0.140			
Lower-bound	45.617	58.000	0.787			

Note: Factor 1 refers to the within-subject variation; Factor 1 Groups refers to within-groups variation.

Table 11. *Pair-Wise Comparisons*

(I) Groups (J) Groups	Mean Difference (I-J)	Standard Deviation Error	Sig. a	95% Confidence Interval for Difference a	
				Lower Bound	Upper Bound
Experimental Control	0.845*	0.94	.000	0.657	1.657
Control Experimental	–0.845*	0.94	.000	–1.034	–0.657

Note. *The mean difference is significant at 0.05 level.

The *F* value ($F = 80.37$), shown in Table 12, indicates an interaction between the two groups (the effect of inter-group factors).

Table 12. *Tests of Between-Subject Effects*

Source	Type III Sum of Squares	*df*	Mean Squares	*F*	Sig.	Partial eta Squared
Intercept	3709.63	1	3709.63	3476.51	.000	.98
Groups	85.76	1	85.76	80.37	.000	.58
Error	61.88	58	61.88			

To answer the third research question, the researchers had members of the experimental group participate in a structured interview that required about 10 to 15 minutes for each learner. Their voices were recorded and analyzed by the researchers. The seven questions learners were asked are shown in Table 13. The analysis showed that 28 learners (90%) were absolutely positive regarding adopting new identities, as asked in Question 1. However, two of them preferred routine activities. Moreover, 88% believed that writing from another person's point of view made writing easier for them (Question 2) because it directed their thoughts. Half of the students (50%) asserted that writing was a terrifying task, as they did not know what to write about. Twelve students (40%) acknowledged that they did not consider writing a pleasant task because they did not like to be judged for their ideas. These students believed that writing with

another person's identity reduced their anxiety and let them feel free to express their ideas without worrying about being criticized.

Students provided a variety of answers to Question 3. Some highlighted the game-like nature of the technique (20%), while some others (40%) believed that it stimulated their imagination. Three of the students (10%) asserted that the technique caused cognitive fatigue as they tried to think about the imaginary characters and settings, and 30% of the students asserted that they liked the technique because it was a totally new experience. All students emphasized the role of classroom atmosphere in reducing anxiety.

Table 13. *Interview Questions*

No.	Question
1	Did you like adopting a new identity?
2	Do you think it made writing compositions easier? Why?
3	In your idea, what was the most important feature of the technique?
4	Did you check the Internet or any other sources before getting started?
5	What language features did you look for?
6	Did the sentences starters and words help you?
7	To what extent do you think the technique helped you know about the foreign culture?

Also, all stated that, during the treatment, they always tried to check "how something is said" in English; they declared that the technique had forced them to become conscious about the forms and features of the language while writing (Question 4). The analysis of the answers to Question 5 showed that the students mostly looked for idiomatic expressions, phrasal verbs, and discourse markers. Furthermore, in response to Question 6, all students believed that the sentence starters provided by the teacher helped them sound "native-like." Additionally, when responding to Question 7 regarding the foreign culture (English or American, depending on the character they had selected), 60% of the students affirmed that they had to read and search different sources before writing.

Discussion

The results of the study denoted that adopting a new identity could improve the participants' writing ability. Imagining a new situation in which one must act seems to foster creativity since imagination is the "cause of creativity" (Lipman 1980, p. 38). If imagination is considered as a skill, then new identity can improve writing through "a great deal of practice" (Lipman, 1980, p. 38). The sequential or episodic nature of the technique helped the students write persistently while imagining themselves in different situations for a variety of purposes. The opportunity to view the world from a different perspective helped the learners look for social and cultural values of the target language. According to Adair (2007), "imaginative thinking supplemented by

intuition" gives the learners some "clues" or "guesses" to relate to real life situations (p. 116). It can be asserted that when students write about an imaginary self-created life, as Adair (2007) argued, they can make "at least some of it up as [they] go along" (p. 116). They try to "take a creative approach to life" which changes their perspective (p. 116).

Thinking as an essential aspect of writing assists learners in making "conceptual decisions" about how to "select, . . . describe, . . . [and] include" (Lipman, 1980, p. i). Hence, the technique used in this study seemed to be a good practice for giving direction to the students whose writing "wander[s] from paragraph to paragraph" (Paul & Elder, 2003, p. 3) without any decision as to the progress of events or sequence of actions. It helped learners to avoid becoming "fragmented" in writing (Paul & Elder, 2003, p. 3), to be able to continue a line of thinking, and to experience a smooth transition from thinking to writing.

Also, its game-like nature promoted imagination and allowed learners to write freely about their emotions and thoughts. Similar to the function games have in language teaching, the technique seemed to lower the learners' anxiety as they started to write; it helped them focus on the task (Richard-Amato, 1988). In line with Lozanov and Gateva (1988), the present study showed that the technique gives emotional stimulus to learners, constructs a pleasing atmosphere for learning, and affects students' personality from both physical and psychological senses (Lozanov, 1978). It seems that the learners could use the technique as "a mask to hide behind" (Stevick, 1980, p. 236) and feel free to make mistakes, which is the best environment for creativity (Adair, 2007, p. 118).

Another positive point of the technique is that it gives teachers the chance to create various contexts within which students can exchange information (Wright, Betteridge, & Buckby, 1984). Writing with a new character motivates language learners to have inner dialog and evaluate the conformity of their writings with the logic of the real world. When learners adopt new identities, they engage in creating a character who talks about his or her life. This kind of writing, as Fletcher (1993, p. 68) put forward, has "voice"; that is, "written words carry with them the sense that someone has actually written them." As a result, the writing becomes interesting and pleasurable to read. As Fletcher maintained, "Writing with voice has the same quirky cadence that makes human speech so impossible to resist listening to" (p. 68).

A positive answer to the second research question confirmed that the new identity technique affected the writing achievement of the experimental group. To put it differently, the repeated measures ANOVA showed that the learners had a gradual development during the treatment. The statistical analysis revealed that the experimental group's mean score for each composition (one to eight) was higher than that of the control group. Thus, it could be concluded that the experimental group benefited more from the treatment than did the control group.

The analysis of the interviews substantiated the results of the statistical analysis, suggesting that the learners were mostly positive with regard to the technique. Interesting points could be inferred about the manipulation of the technique. The students' assertions implied that they could have a better understanding of the context of English-speaking countries. For instance, one of the learners who had selected to be *Richard Michael, an English person living in London,* claimed, "When I think I am a person living in an English speaking country, I try to produce an accurate language with appropriate words." The participants thought they could follow an order while writing and felt they could think in an organized manner. Also, they contended that beginning to write seemed easier for them since they were motivated to write with their new identities. The girls were more positive than the boys in their responses. Notably learners' attitudes indicated that they enjoyed the technique and were satisfied with creating an imaginary identity. Learners

stated that the technique was an opportunity to create a native-like environment and become accustomed to its culture. Moreover, they maintained that conventional teaching methods and related activities, tasks, and assignments in the previous writing classes seemed boring. One of the students who had selected to be *Catherine Mackay* contended, "it is very interesting for me. This way, I think as if I am a native speaker and can write as I wish. I have more control over the material I tend to write." Another student who was *Peter Williams* in his new character asserted, "I thought a lot about my writings and tried to prepare them within a real-life context." One of the students, who had adopted to be *Dr. Jane Andrews*, stated, "Now, I am interested to study harder and be a doctor in future." Her claim reminded us about Adair's (2007) assertion that "creative thinkers" see life as a "series of beginnings" (Adair, 2007, p. 117).

Conclusion and Implications

Findings of the present study propose that adopting a new identity can motivate learners to engage in writing tasks. Its game-like nature places learners in an imaginary situation leading to the stimulation of creativity. Learners, hidden behind a new character, feel free to travel to different places and create their lives as they prefer. The technique can encourage learners to write willingly, without considering writing chores to be boring or mandatory. Also, the method might interest EFL/ESL teachers who search for innovative techniques in language teaching and think that learners' sense of wonder in the classroom can enhance learning. However, making any generalizations regarding the results of this study is impossible before teachers and practitioners implement the technique and discover whether they can support the findings. The study has an implication for those language teachers who believe in the manipulation of techniques that are different from classroom routines.

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Assessment and Evaluation

What Does Indirect Assessment Tell Us?

Nataliya Serdyukova

Abstract
Indirect assessment allows educators to obtain valuable data that can be used for the enhancement of teaching and learning. This paper reports a pilot study of students' perceptions about two courses in General Physics taught in different formats using a survey as an indirect assessment instrument. The study aims to identify key issues in the course content, structure, and delivery; to appraise and compare these courses; and to develop recommendations for improvement.

Key Words
Assessment, indirect assessment, physics, course format, student perceptions

Introduction

Quality teaching and learning depends on numerous factors, among which assessment is critical. Assessment is vital for improving both student performance and instructor's teaching (Wiliam, 2011). As indicated in Stiggins (2006) article, "Assessment for Learning," "Profound achievement gains can be realized with effective, formative, classroom assessments . . . Educators must use the evidence gathered through assessments for two purposes: to inform instructional decisions and to encourage students to try to learn" (p. 1). Therefore, the two major goals of assessment are for the instructor to improve the teaching and for the student to improve the learning. While some assessments are designed mainly to provide accountability of teaching and learning (e.g., standardized tests), the primary mission of assessment is undoubtedly to collect the data that will be analyzed and used to improve the learning. Therefore, the main function of assessment is to assure the quality of learning. Despite numerous publications on assessment, the issues of its efficiency, and particularly of its impact on teaching and learning, require continuous research. This article presents the findings from indirect assessment of student perceptions from two General Physics courses taught in different time formats, one month and two months. Physics courses were begin at National University quite recently, 10 years ago, and during this time enrollment has grown continuously, from 14 to 168 per year (as of 2013). Physics presents significant difficulties to many students; hence the author attempted to identify, using indirect assessment techniques, what in these courses raises concern for students. Indirect assessment serves as a starting point for improvements in the course, and is a way to recognize how indirect assessment can help advance both teaching and learning.

Assessments in University Teaching and Learning

Universities use various types of assessments. There are formative and summative assessments. The first focuses on the dynamics of the ongoing learning process; the second on static terminal results. It is apparent that formative assessment is closely involved in the learning process: "Formative assessment centers on active feedback loops that assist learning" (TEAL, 2012, para. 2). While we know that formative assessment provides immediate feedback and support for students, thus stimulating their achievements, "the interest (and investment) in summative assessment has far outstripped that accorded to formative assessment" (Stiggins, 2006, p. 236).

The evidence is supplied by the tremendous growth of standardized (summative) testing in U.S. schools, which actually dictates what students should learn in school and serves predominantly for accountability purposes. There are also direct and indirect assessments that are the most widely used for measuring both student performance and learning outcomes.

Direct assessment is the "assessment of student learning that occurs during the instruction experience; when students participate in an activity or exercise that requires them to demonstrate the extent of their learning" (*Assessment Vocabulary*, 2013, p. 2). Direct assessment is based on the analysis of students' behaviors or products in which they demonstrate how well they have mastered learning outcomes (Allen, 2008). Direct assessment uses such tools as quizzes, exams, essays, homework, and class participation.

Indirect assessment is the "assessment of student learning based on opinions or perceptions obtained from students or faculty, often collected through the use of supplemental surveys, student evaluations or focus groups" (*Assessment Vocabulary,* 2013, p. 3). It also involves the instructor's observations, a continuous analysis of a student's performance, and study of reported perceptions about the student's learning process and mastery of learning outcomes (Cooper, 2006). Indirect assessment is believed to be the least intrusive and stressful type, which thus may be more objective than many other assessments and yield better information on students' perceptions, performance, and achievements in the class (Floyd, Phaneuf, & Wilczynski, 2005). Perceptions may be recorded through self-reports by students or made by others, such as alumni, fieldwork supervisors, employers, or faculty (Allen, 2008). Indirect measures assess opinions or thoughts about student knowledge, skills, attitudes, learning experiences, and perceptions. Allen (2008) listed the following strategies for indirect assessment of student learning: surveys, interviews, reflection and self-evaluation, ratings, student evaluations of instruction, and focus groups. Actually, indirect assessment is an informal observation and analysis of student's performance that is intended, via feedback, to help the student identify his or her problems and overcome them. At the same time, it gives invaluable information for the instructor who, upon evaluating it, can make research-based, verified conclusions about various aspects of the course and his or her teaching, which may be helpful in updating the course delivery and instructional approaches. Indirect assessment can either complement or augment direct assessment, or provide additional insight into the learning process.

Indirect assessments help educators provide differentiated instruction and thus improve student achievement. According to Guskey (2007), for assessments to become an integral part of the instructional process, teachers need to change their approach in three important ways. They must "1) use assessments as sources of information for both students and teachers, 2) follow assessments with high-quality corrective instruction, and 3) give students second chances to demonstrate success" (p. 16). They also offer students unique opportunities to reflect on their learning, which may be helpful in the development of effective learning skills. Stiggins (2007) suggested that the student's role in assessment is to strive to understand what success looks like and to use each assessment to try to understand how to do better the next time.

Survey, Data, and Discussion

A pilot study to appraise the General Physics courses using indirect assessment was conducted in eight student groups covering 107 students. The students were all adult learners (ages 25–54), racially and gender diverse. The courses were taught at National University, San Diego, California, USA, during the years 2012–2014. The instrument of indirect assessment was a

student survey specially designed for this study. The method was based on the Assessment Loop (Wright, 2009) consisting of four stages: (a) questions, (b) gathering evidence, (c) interpretation, and (d) use.

In the first stage, a survey with 14 questions was developed focusing on students' expectations for the class, difficulties they encountered, factors affecting their performance, and so on. In the second stage, students anonymously completed the surveys. In the third stage, the information obtained was interpreted. In the fourth stage, the results of this experiment were used to update the course. Statistical analysis was based on chi-squared (χ^2) distribution.

PHS 104 and PHS 171-172 are two courses covering the same content; however, PHS 104 is taught in a one-month format, whereas PHS 171-172 is extended over two months' time. The extended time of PHS 171-172 allows the instructor to increase the content in breadth and depth. The data received in the survey were analyzed and compared between these two courses. There were 63 students in five PHS 104 and 44 in three PHS 171-172 classes. The data presented in the tables include only the responses to which at least 5% or more students responded.

According to Table 1, the difference between the two sets of responses by the courses was statistically significant at the $p < .005$ level, which indicated the substantial variance between them, thus allowing the author to make the following conclusions. The main expectation for the students in both PHS 104 and PHS 171-172 was to gain a solid foundation of physics, which was considerably higher in the PHS 171-172 classes. This specified the ultimate purpose for students' taking these classes, while demonstrating that students taking an extended sequence of Physics were more interested in this outcome than were their counterparts. All other expectations were related to students' lesser concerns—that the class would be very difficult and too fast, for which students taking a one-month PHS 104 course indicated a notably higher apprehension. The anxiety over the good grade was not too high and was nearly the same in both sets.

Table 1. *What Were Your Expectations for the Class?*
(Percent of Students Responding)

Questions/courses	PHS 104 (%)	PHS 171-172 (%)
Gain solid foundation of physics	54.9	68.5
Very difficult class	33.7	20.8
Get a good grade	6.2	7.9
Fast-paced	5.2	2.8

$\chi^2 = 13.12$; $p < .005$ (12.84, $df = 3$).

The concern over class difficulty could be explained primarily by students' fear of math, as will be shown later in this article, and insufficient time assigned for mastering difficult content. The latter factor was confirmed by their concern over the fast-paced course delivery: 5.2% vs. 2.8%, which indicated that time allocated for learning physics in PHS 104 class was considered to be insufficient by some students. The number of students hoping for a good grade (6.2% and

7.9%) suggested that students may feel their previous preparation would be inadequate for this complex course.

Remarkably, PHS 171-172 students were more conscious of learning the subject and less worried about its complexity, as could be explained by the fact that they would have twice as much time for learning than their counterparts, which lowered their anxiety.

Table 2. *When You Came to the Class, What Were Your Concerns and Fears? (Percent of Students Responding)*

Concerns/courses	PHS 104 (%)	PHS 171-172 (%)
Mathematics	32.7	36.7
Physics content	25.5	34.7
Fast-paced courses	17.3	14.3
Grade	14.3	5.1
None	10.2	9.2

$\chi^2 = 20.21$; $p < .001$ (18.47, $df = 4$).

In Table 2, the difference between the two sets of responses by the courses was also statistically significant at the $p < .001$ level; therefore the following conclusions were made. The students' major concerns before the class were related primarily to math, which was similar in both sets of classes (see Table 4), and then course content, which was statistically more significant in the second set of PHS 171-172 responses. Students in PHS 104, who studied mostly in engineering specializations, probably regarded this class as a less challenging general-educational one. Mathematics preparation for students enrolling in Physics classes, as revealed both from this research and personal experience, seems to be quite deficient. Considerable anxiety was also caused by the accelerated course format and the potential grades, which was more expressed in PHS 104, as shown in Table 1. PHS 171-172 students may have had higher motivation and better attitude towards this class in which they wanted to succeed, as they would need physics proficiency for their future jobs (since the better part of them majored in biology), which was confirmed by subsequent data (see Table 5). At the same time, some students were still unsure of their readiness for this course, especially in PHS 104, which was expressed in their concern over the grade.

As demonstrated in Table 3, where the difference between the two sets of responses by the courses was statistically significant at the $p < .001$ level, the concerns and fears had subsided in both classes by the end of the course, though to a much lesser extent in PHS 104, probably because many students' worries over math and physics were confirmed based on the instructor's assessment of students' assignments (mainly in the area of problem solving). This observation again pointed to their insufficient general math and science preparation before the classes, and to an accelerated class format. It appeared that the longer students were in the class, the lower was their anxiety.

Table 3. *Have Your Concerns and Fears Subsided by the End of the Course? (Percent of Students Responding)*

Student responses	PHS 104 (%)	PHS 171-172 (%)
Yes	66.3	94.2
No	33.7	5.8

$\chi^2 = 142.47$; $p < .001$ (10.83, $df = 1$).

Table 4. *What Was the Most Difficult for You in the Class? (Percent of Students Responding)*

Items/courses	PHS 104 (%)	PHS 171-172 (%)
Math and the use of formulas	43.5	49.0
Comprehending the problems	29.1	36.2
Everything	7.3	7.4
Exam	6.8	0
Amount of material and time	13.3	7.4

$\chi^2 = 6.72$; $p > .05$ (9.49, $df = 4$).

In Table 4, the difference between the two sets of responses by the courses was statistically insignificant at the $p > .05$ level. The two sets of similar responses—students' concerns over math and physics content—were substantiated during the class in both courses, particularly regarding students' use of formulas and in their comprehension of the problems.

It was more noticeable in PHS 171-172, possibly because of the greater volume and depth of the course content in this course sequence than in the PHS 104; compare with Table 3. Quite a few students lack conceptual understanding of major math and physics laws. When students do not comprehend a problem, they are unable to identify and use the right formulas for solving it. The concerns over the amount of material and time, as well as the exams, were significantly higher in PHS 104, possibly due to the aforementioned shorter course format.

Table 5 shows that though the difference between the two sets of responses was statistically significant, the students were generally appreciative of the professor's work in both courses. However, the role of the professor in the short PHS 104 course was perceived as more important than in the longer PHS 171-172 course. It appears that students in the former class counted more on the instructor's support, while in the latter they were better prepared and consequently felt more independent. Improved understanding of physics was achieved in both classes—28.1% for PHS 104 and 32.6% for PHS 171-172, and some students (almost twice as many in

PHS 171-172) alluded to the potential application of physics on the job, which showed the students in the latter class were more job oriented.

Table 5. *What Was the Most Useful for You in the Class?*
(Percent of Students Responding)

Items/courses	PHS 104 (%)	PHS 171-172 (%)
Professor	59.6	43.8
Understanding of physics	28.1	32.6
Potential application on the job	12.3	23.6

$\chi^2 = 11.73$; $p < .005$ (10.60, $df = 2$).

Table 6. *Has the Class Met Your Expectations?*
(Percent of Students Responding)

	PHS 104 (%)		PHS 171-172 (%)	
Questions/courses	Yes	No	Yes	No
Satisfaction with the class	93.7	6.3	93.0	7.0

$\chi^2 = .08$; $p > .05$ (3.84, $df = 1$).

According to Table 6, where there was no significant difference between the two responses, students were generally satisfied with the class, which met their expectations—93.7% and 93.0% respectively—which showed no statistically significant difference between the two courses. This indicated their appreciation of the quality of teaching and learning in these classes.

Regarding students' satisfaction with their own accomplishments (Table 7), with some statistical difference between the two sets of responses, 69.0% in PHS 104 and 78.1% in PHS 171-172 stated they were satisfied. At the same time, 31% of students in PHS 104 and 21.9% in PHS 171-172 indicated they were not satisfied. This finding was related to their identification of difficulties (see Table 4), which showed that some students were unable to completely master the course. It is evident that the two-month class format gives students more time to achieve their desired outcomes and thus brings more satisfaction.

Table 7. *Have You Been Satisfied with Your Own Accomplishments?*
(Percent of Students Responding)

Questions/courses	PHS 104 (%)	PHS 171-172 (%)

	Yes	No	Yes	No
Satisfaction with own achievements	69.0	31.0	78.1	21.9

$\chi^2 = 4.84$; $p < .05$ (3.84, $df = 1$). Approaching $p < .025$ level (5.02, $df = 1$).

Despite some students' disappointment with their own accomplishments, it follows from Table 8 that it was not connected to the quality of the teaching, which in both courses showed 100% satisfaction with the instructor.

Table 8. *Have You Been Satisfied with Your Instructor? (Percent of Students Responding)*

	PHS 104 (%)		PHS 171-172 (%)	
Questions/courses	Yes	No	Yes	No
Satisfaction with the instructor	100	0	100	0

$\chi^2 = .00$; $p > .05$ (3.84, $df = 1$).

It is noteworthy that, as shown in Table 9, 56.3% and 67.9% of students in each course, respectively, did not suggest any improvements, which is probably related to their high satisfaction with the course (see Tables 6, 7 and 8). The statistical difference between the two sets of responses was significant. Many (38%) of the PHS 104 students felt they needed more time for the course, while in PHS 171-172 only 10.7% of students felt this way. Some students, particularly in PHS 171-172 classes, would have liked to have Trigonometry taught before Physics. It is evident that students who want to prepare well for the job and to master physics need a better math preparation.

Table 9. *What Would You Suggest to Improve in the Class? (Percent of Students Responding)*

Questions/courses	PHS 104 (%)	PHS 171-172 (%)
Nothing	56.3	67.9
Trigonometry before Physics	5.7	21.4
More time	38.0	10.7

$\chi^2 = 83.15$; $p < .001$ (13.82, $df = 2$).

To obtain better insight into the courses' delivery, the study asked the students how much time per week they spent on learning outside the classroom; the results are reported in Figure 1.

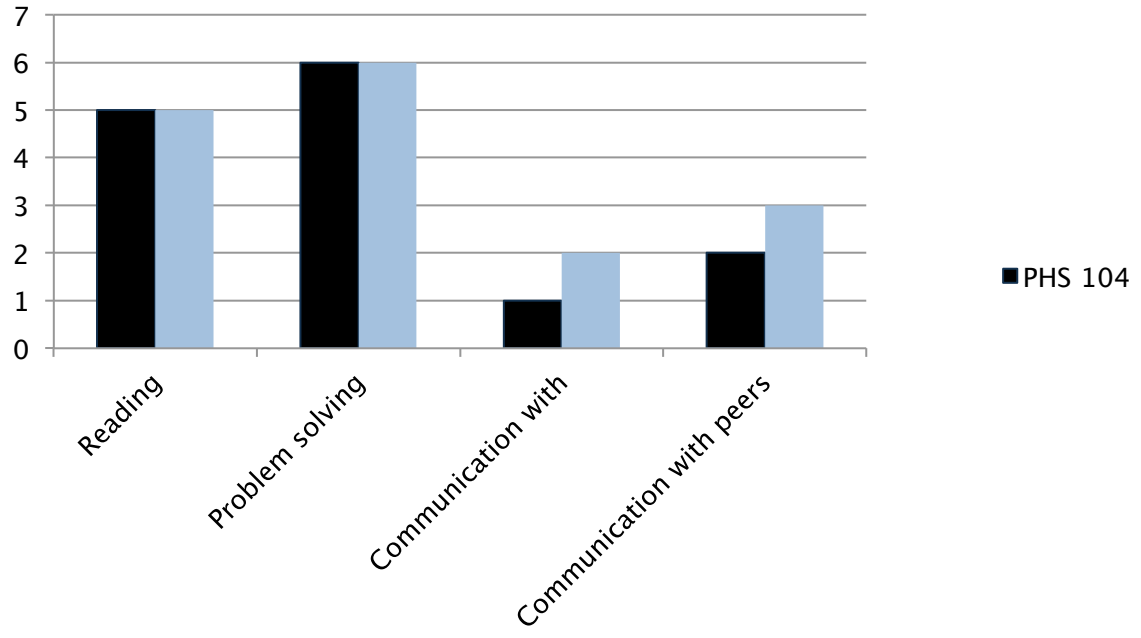

Figure 1. Time spent on major class activities in hours per week.

The data presented in Figure 1 show that students in both classes spent equal time—6 hours on solving problems (homework), and 5 hours on reading. In the two-month course, however, they spent more time on learning and communicating with the peers and the instructor, evidently because in a longer class they had a better opportunity to develop closer relationships with them. These data can help both the instructor and students improve time management in the course.

Students' responses to the open-ended question, "What have you learned in this class, in addition to the new knowledge in content area?" were quite demonstrative:

- I have learned how and why all these laws make sense.
- I understood interconnectedness of physics concepts.
- I need to improve my math skills.
- Thanks to the physics, we began to better understand math.
- My math skills became less rusty.
- This helped me develop better study skills and become a better listener.
- To success in learning I must work hard.
- Being persistent pays off in the end.
- I learned not to be afraid of the difficulties.
- I learned how to manage my time better.
- Helps to think more critically.
- Attitude is everything.

- I am no longer shy in front of the classroom.

These responses could be divided into three groups:

1. A more holistic and systemic understanding of physics.
2. Improvement of mathematics skills.
3. Enhancement of cognition and learning skills.

This observation demonstrated that students in these courses appreciated not only a direct effect of taking these classes through growth in the course content knowledge, but also an indirect effect in learning through growth in the major related area of math, as well as in their learning skills.

Application of the Findings

Based on the findings, the following suggestions for the modifications to the courses and improvement of the learning outcomes were put forward:

- In PHS 104, to remediate the situation with insufficient math preparation, the university must make college algebra and trigonometry courses MTH 215 or MTH 216A and 216B prerequisites, not co-requisites.
- Instructors need to carefully select and organize the learning materials, adapting the course content to the students' preparedness in physics.
- In both classes, student advising, consulting, and mentoring by the instructor before, between, and after classes is necessary to alleviate individual and common issues associated with the competence level.
- It is imperative that universities and high schools match their entrance and exit requirements to ensure smooth transition of school graduates to the university classes.

Integrated University Assessment System

Though assessment is crucial for improvement of learning outcomes, alone it will not make a significant mark on either the teaching or the learning. Even the end-of-course evaluations students typically take in every class have an insufficient effect on the general instructional culture and on the teaching (Chen & Hoshower, 2003, Subramania, 2014). So while it falls primarily to the instructor to make good use of the feedback, the institution's culture may not be affected by it.

As it has become clear that assessments used by the individual instructor in their courses will not have a big effect on the university's teaching quality, the author believes it takes an integrated approach involving various elements of the academic institution to make a significant change in learning outcomes. However, according to Ruben (2007), an integrated, systematic, campus-wide approach to assessment, planning, and improvement is often lacking. According to Stiggins (2006), "Assessments must go beyond merely informing the instructional decisions of school leaders to informing decisions made by students and teachers, too. This means that we will need to design balanced assessment systems that serve diverse purposes by meeting the information needs of all decision makers" (p. 3). One of the prospective venues in this direction may be the creation of

> . . . an institution-wide assessment and information system . . . It would provide constant, useful feedback for institutional performance when it is made available to the faculty members. It would track transfer, graduation, and other completion rates. It would trace the flow of students through learning stages (such as the achievement of basic skills) and the development of in-depth knowledge in a discipline. It would measure the knowledge and skills of program completers and graduates. It would assess learning along many dimensions and in many places and stages in each student's college experience." (Barr & Tagg, 1995, p. 9)

Such an assessment system should serve all stakeholders in many ways.

Thus, assessment should be regarded as one of the tools of the university culture focused on continuous improvement of teaching on the basis of reflection, self-assessment, analysis of internal and external assessments, and continuous learning. The author proposes a university-wide instructional system integrating ten essential components in which the instructor interacts with them, as shown in Figure 2:

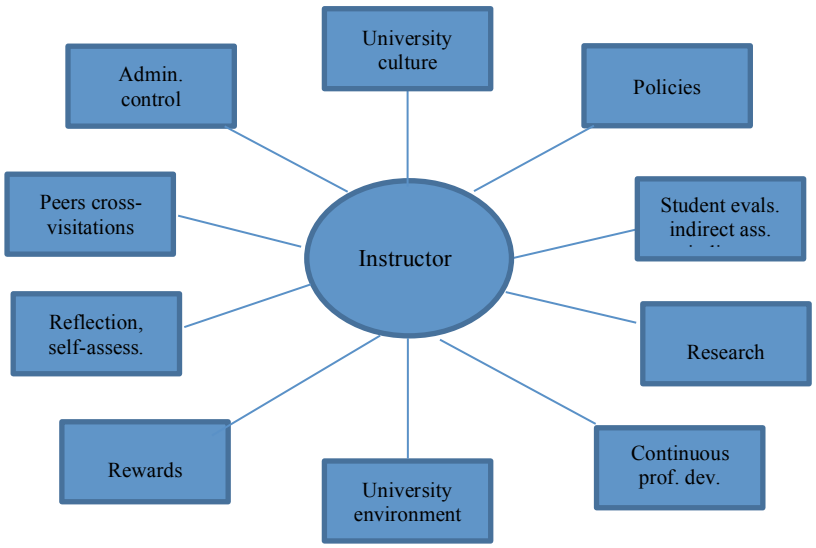

Figure 2. Integrated university assessment system structure.

1. University culture
2. Policies as the foundation of the culture
3. Administrative control
4. Rewards for excellent performance (merit; best teacher of the year)
5. Faculty reflection and self-assessment
6. Peers' cross-evaluation through class visitations and collaboration as a norm
7. Student evaluations and indirect assessments
8. Continuous professional development (prof. dev.)
9. Research of instructional practices (including action research)
10. University environment, comprising onsite and online classes, administrative and technical support, particularly advisors, and faculty learning community

All these elements are interrelated and must work in concert. Integration of assessments into all ten components will serve as a catalyst for the systematic progress of teaching and learning across the university. In addition, school-wide "assessment can help ensure that institutional resources are being spent in the most effective ways possible—where they'll have the greatest impact on student learning" (Suskie, 2004, pp. 11–12). The data from assessments can also serve as valuable material for faculty research focused on improving teaching and learning.

Conclusions

Indirect assessment can play an important role in the appraisal of the courses and their teaching. It may bring to attention some course imperfections related to the design, format, content, or delivery methods. It also displays students' concerns, which can then be addressed in course development, preparation and teaching. The present study revealed significant flaws in students' preparation in math and sciences at school and in the part of the program preceding Physics. To remediate this situation, the university must make College Algebra and Trigonometry courses MTH 215 or MTH 216A and 216B prerequisites, not co-requisites.

As has been demonstrated in this paper, students taking General Physics courses need better preparation in math, more time for mastering the course concepts and developing problem solving skills, and continuous instructor interaction and support during the class. It became evident, based on this study, that an extended, two-month course model for learning General Physics may be preferable to an accelerated one-month model. More significant than an individual instructor's assessment seems, however, is the need to establish an institutional culture of continuous improvement that will rely not solely on the end-of-course evaluations and instructor's in-class direct and indirect assessments and evaluations, but also on the continuous university-wide integrative effort to improve the quality of learning outcomes. Course assessments will have a greater effect if they are a part of the institution-wide assessment system and culture.

Acknowledgement

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Improving the Uniformity and Consistency of the End-of-Course Evaluation Response Mappings to Numerical Quantities by the use of Fine-Grained Answers and Guidelines

S. R. Subramanya

Abstract

Despite being administered for over fifty years and studied extensively, no single end-of-course evaluations scheme has emerged that is uniform and consistent. One of the main problems is the lack of precise guidelines available to students to help them to precisely determine the number (on a Likert-type scale) that is the most appropriate response for a given question. This article proposes a scheme that provides a set of fine-grained answers to each question and a simple but well-defined set of guidelines for answering the questions. These are expected to improve the uniformity and consistency of the student responses.

Key Words End-of-course evaluations, student evaluations, fine-grained answers, guidelines, uniformity, consistency

Introduction

The end-of-course (EoC) evaluations are performed by students at the end of the courses in almost all institutions of higher learning. The EoC evaluations, overall, have remained unchanged. The process consists of the students' answering a questionnaire as a means of providing feedback to the instructors about how the students feel about their learning experiences, the course content, and the instructor's teaching.

The life cycle of a typical (traditional) course delivery is shown in Figure 1. There are five distinct parts or components in this course delivery model:

1. The instructor uses the course content (consisting of textbook, supplemental material, class activities, etc.) to develop the course delivery content.
2. The instructor performs instruction and delivers the course content.
3. The student participates in the class activities and also uses the course content in order to learn.
4. The instructor administers assessment of student learning of course content (consisting of homework, quiz, exam, project, etc.).
5. End-of-course (EoC) evaluation is performed by the students by completing the forms. These EoC evaluations are conveyed (with anonymity) to the instructor.

The results of EoC evaluations are used for making several important decisions such as tenure/reappointment, promotion, and merit increases. Thus it is extremely important to ensure fairness and accuracy of the outcome of the EoC evaluation process. The students are not provided with any tools or guidelines in performing the mapping of a verbal question to a number, and it is left to their "feelings." This article focuses on a particular aspect of the EoC evaluation process by students and proposes a scheme for improving the uniformity and consistency of the process of mapping, taking questions in the questionnaire to a numerical quantity on a Likert-type scale.

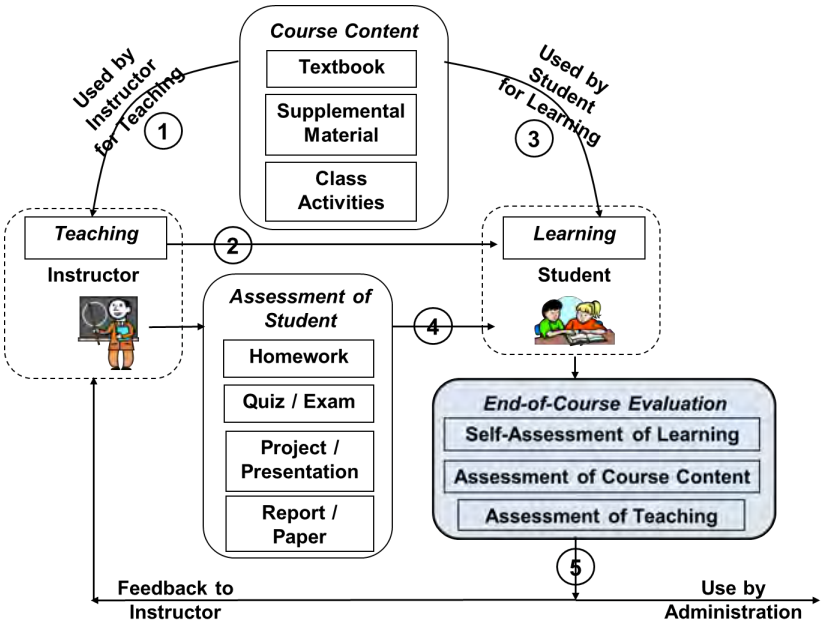

Figure 1. The flow of activities in a typical "life-cycle" of a typical (traditional) course delivery.

Numerous studies have shown that the EoC evaluations are not very effective for a variety of reasons; one of the reasons is the lack of clear instructions/examples to students to map the answers in the questionnaire to the proper number (in the Likert-type scale), which leads to inaccurate and inconsistent numbers. For the questions in the questionnaire, there is absolutely no clear-cut and unambiguous method that the students are required to follow in assigning a number to a question. No guidelines or aids are available to students to determine what number more accurately corresponds to the answer to a question. This results in a mismatch between the ideal and actual mappings and leads to errors in the evaluation numbers, as shown in Figure 2.

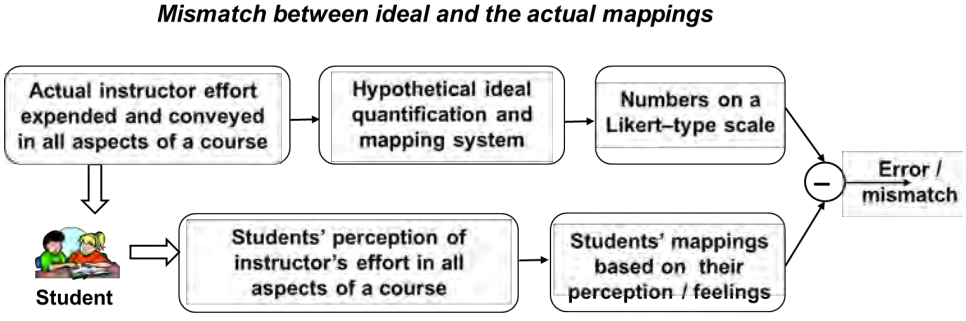

Figure 2. Mismatch between the ideal and actual mappings.

Although each student's experience in a course is different, a number of questions should elicit uniform answers from the students, irrespective of the their individual backgrounds and

preparation. Answers to questions should be based on objective quantification of the efforts of the instructor and effectiveness of those efforts in all the relevant aspects of the course.

The objective of the proposed scheme is to improve the uniformity and consistency in the mapping of the EoC evaluation responses to numerical quantities by the students. In the context of this article, *uniformity* is defined as the closeness of unbiased answers to a given question across students, and *consistency* is defined as the closeness of unbiased answers to the questions in the questionnaire by a given student. An important assumption is made, that the instructor is given the benefit of doubt: If a student's rating of a given course/teaching attribute is greater than that of the number produced by the automated mapping system, then the higher value is retained.

The proposed scheme essentially breaks down the answer to a question into well-defined, *fine-grained answers* that the students choose from. These fine-grained answers are designed to lead to the most appropriate and objective answer to the original question. In conjunction with a simple set of guidelines with examples, this facilitates the students' mapping of the answers to the questionnaire questions to numbers in a uniform and consistent manner.

In this article, the terms *instructor* and *faculty* are used synonymously. The rest of the article is organized as follows. The next section presents a brief background of the current EoC evaluation drawbacks. This is followed by the section highlighting the drawbacks in the current evaluation model of the mapping by the students of their responses to verbal questions in the questionnaire to numbers on a Likert-scale. Then, a scheme is proposed that incorporates the fine-grained answers and guidelines in order to improve the mapping. This is followed by conclusions.

Background

End-of-course (EoC) evaluations seek to find out the students' perception and experience of the instruction of the course, several traits of the instructor relevant to course instruction/delivery, and course content. The ultimate objectives of these evaluations are, or should be, to use them as productive feedback in order to improve the quality of instruction and enhance the learning experience of the students. This section gives several samples of work done in this area, starting with some old ones from almost 35 years ago and through the years to the more recent ones. This is done to sample the kinds of issues researchers in the area have tackled over the years, and to present the observation that the same or similar problems have persisted over time.

Studies have been made over the decades and literally thousands of research papers have been published, focusing on the nature, methodology, and validity of student evaluation of teaching (EoC evaluation data). At the end of 2010, there were 2,875 references in the ERIC database using the descriptor "student evaluation of teacher performance." By the additional descriptor "higher education," the number was 1,852 (Benton & Cashin, 2012). Positions have been taken about (a) the capability of students to evaluate objectively, (b) the parameters that can effectively cover the aspects of teaching effectiveness, (c) factors that introduce biases into the evaluations, (d) the very validity of the evaluations, (e) the effectiveness of the evaluations in contributing to the improvement of teaching effectiveness and learning experience, (f) the ways the results of evaluations are (or should be) used by the faculty and administration, etc.

The validity and reliability of the evaluation questionnaires have been the topic of study of a number of papers. Deficiencies in student evaluations of teaching that contribute to inaccuracies in the measurement of teaching effectiveness have been widely discussed (e.g., Calkins & Micari, 2010; Darling-Hammond, Beardsley, Haertel, & Rothstein, 2012; Williams & Ceci,

1997; Wines & Lau, 2006). Many cases of invalidity of student evaluations of teaching were given in Fish (2005), as well as Gray and Bergmann (2003). An extreme case of the absurdity of student evaluations was documented in the "Dr. Fox Experiment" (Naftulin, Ware, & Donnelly, 1973), in which a charismatic actor giving a lecture, devoid of any worthy educational content, was rated highly by a well-educated audience. Kember and Leung (2008) provided procedures for establishing the validity and reliability of questionnaires so that the strengths and weaknesses in teaching are easily identified in order that appropriate remedial measures can be taken.

Data from studies by Aleamoni (1987), Arreola (1995), Dooris (1997), Feldman (1978), Sproule (2000), Theall and Franklin (1990), and numerous others have shown that student evaluations of teaching have little to do with learning. These works have been cited here as representative to indicate that over the years, the same problems have persisted.

Emery, Kramer, and Tian (2003) have given a qualitative and quantitative review of student evaluations as a measure of teaching effectiveness, the problems therein, and suggestions to improve them. They gave a very good account of the inconsistencies of student ratings and administrative interpretations of them, based on factual evidence and the personal experience of the authors, along nine different dimensions (attributes): (a) reliable in meeting class, (b) available outside class, (c) grading fair and reasonably, (d) prepared for class, (e) knowledge of subject, (f) excellent credentials but considered average, (g) beneficial lab work, (h) when is "good" good enough? and (i) composition of the composite group.

Behaviorally anchored rating scales (BARS) are scales used to rate performance. These were developed in order to deal with the subjectivity involved in using traditional rating scales. BARS aim to combine the benefits of narratives, critical incidents, and quantified ratings by anchoring a quantified scale with specific narrative examples of good, moderate, and poor performance. Although BARS are often regarded as a better performance appraisal method, it is shown in Kingstrom and Bass (1981) that BARS may still suffer from unreliability, leniency bias, and lack of discriminant validity between performance dimensions.

It is not the intent of this article to address the issues of validity of the EoC evaluations, nor their contributions in improving the teaching effectiveness. Instead, the primary objective is to propose a scheme that "elaborates" on the questionnaire questions, disambiguates them, and attempts to bring more definiteness in their scope. Apodaca and Grad (2005) have shown that, although student ratings are considered to be multidimensional, students give similar ratings across a lot of evaluation items. In our opinion, one of the possible factors for this outcome is lack of explanations and guidelines given to students about the exact intent of the question and what it is trying to measure. The scheme proposed in this article is a step in the direction of bringing more alignment to the numbers that the students give via their evaluations with those numbers corresponding to factual data.

Drawback of the Mapping Process in the Current Evaluation Model

A high-level overview of the current model of EoC evaluation is shown in Figure 3. The students are given a questionnaire covering various aspects of the course and the instructor. The students are expected to map each of the questions to a number on a Likert-type scale. There are no guidelines, examples, or quantifiers available to students in determining, for example, what level of effort by the instructor on a particular aspect of the course would be deserving of a "3," "4," or "5."

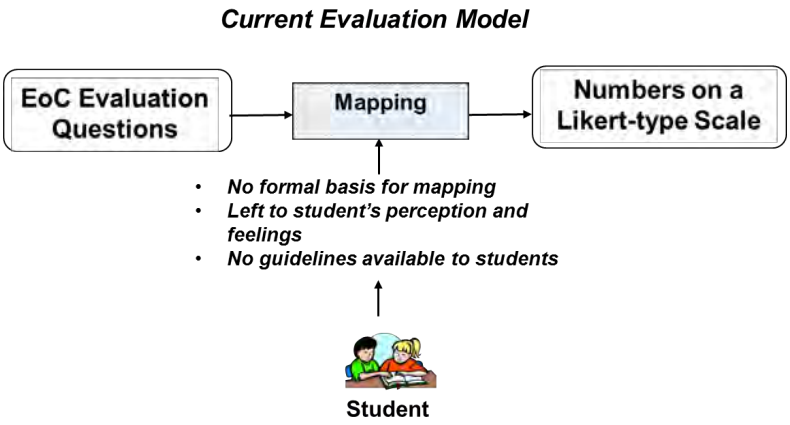

Figure 3. The current model of end-of-course evaluations.

As another example, for a statement such as "Class time was used effectively," absolutely no instruction or direction is given to students regarding what constitutes the activities or the topical coverage that deserves a numeric score of 1 or 2 or 3, etc. In these cases, the evaluation numbers are merely based on the "feelings" of students. Similarly, for questions such as "Instructor provided timely feedback on my work," "The instructor encouraged student interaction," "The instructor was an active participant in this class," etc., the non-availability of tools and guidelines to students to facilitate the mapping (translating) of their answers to numerical quantities leads to non-uniformity and inconsistencies.

Clear, uniform, and objective "rules" are non-existent in assigning the numbers to teaching attributes. Following are a couple of examples highlighting the need for fine-grained answers and guidelines from another perspective. For example, students complete the questionnaire within a few minutes. Their most recent experiences will stand out, which may not be representative of the total, overall effort of the instructor. The provision of fine-grained answers and guidelines alleviates this problem by giving the students a broader view of the possible answers to the question and a better means of quantification.

Students may have unreasonable expectations. In order to achieve accuracies in the responses, it is important that their expectations are conditioned by realities. For example, most students may expect an email response within minutes of sending. This is based on their social media habits and world view. However, instructors have numerous other duties and responsibilities that the students may not be aware of. Therefore, a set of reasonable expectations made known to students in the "Guidelines" would help them in quantifying the appropriate levels of expectations out of faculty, thus minimizing the mismatch between students' expectations and instructors' efforts.

Guidelines for Mapping Answers to Questionnaire Questions to Evaluation Numbers

Guidelines should be extremely simple to follow with the least effort. They should clearly and unambiguously specify, with representative examples, what numbers best represent the responses to the questions according to an objective and fair evaluation. For example, for the question "Makes efficient use of class time," and on a scale of 1 to 5, the corresponding guideline should

specify as clearly and specifically as possible, how the time spent in the class period would qualify for a rating of 1, 2, 3, 4, or 5. The students should be made aware of these guidelines. In spite of these, there may still be biases. However, it will minimize errors due to students' incompetence in assigning proper numbers to the corresponding teaching aspects and/or lack of clarity in the anchors.

Fine-Grained Answers to Questionnaire Questions

Fine-grained answers to a question represent a set of simpler, well-quantifiable answers to the original question. These could be either mutually exclusive or not. These provide a definite framework for mapping a question's appropriate answer to a number. They simplify the seemingly wide range of possibilities to a few well-defined and well-quantified possibilities. This assumes the availability and use of an automatic mechanism for translating responses to fine-grained answers to the appropriate number on the Likert-type scale.

Mapping Process in the Proposed Scheme

It is important to make the students aware of the appropriate mapping, taking into consideration well quantified guidelines and fine-grained answers to questions. This would lead to the course/instructor evaluations by students' being more uniform and consistent. In order to achieve this result, It is proposed to use fine-grained answers and guidelines made available to students in the evaluation/mapping process, as shown in Figure 4. This inherently increases the uniformity and consistency in the way students' responses are quantified and mapped to a number on the Likert-type scale. As described earlier, *uniformity*, with respect to a question, refers the closeness of (unbiased) answers to the given question across students, and *consistency*, with respect to a student, refers to closeness of (unbiased) answers to all the questions by the given student.

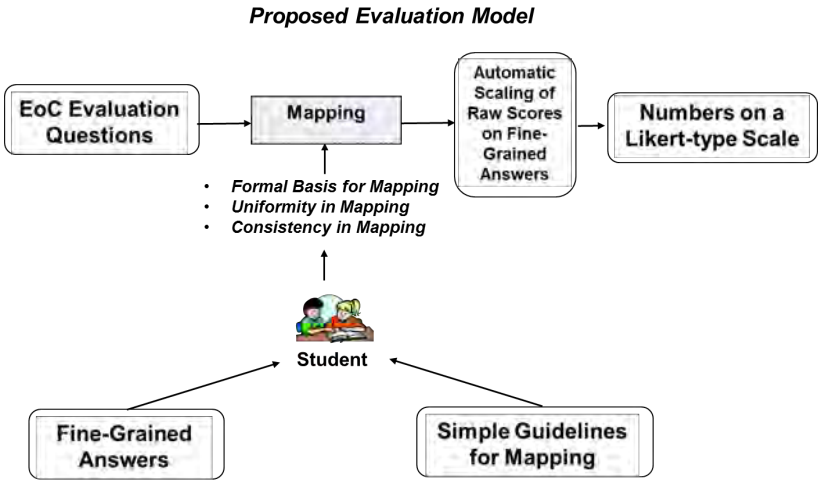

Figure 4. Transformations to enhance the relevancy of raw data.

Uniformity and Consistency

Following is a listcontaining the terminology and definitions leading up to the formal definitions of uniformity and consistency.

N: Number of questions in the questionnaire
M: Number of student responses
$r_{i,j}$: Response to question i by student j, $1 \leq i \leq N$, $1 \leq j \leq M$
a_i: Answer to question i by the hypothetical ideal mapping system, $1 \leq i \leq N$
dS_j: Deviation of the responses of student j across all questions i, $1 \leq i \leq N$
dQ_i: Deviation of the responses to question i of all students j, $1 \leq j \leq M$
R: Response matrix

□1, 1□1, 2□2, 1□2, 2.....□1, □.□2, □.....□□, 1□□, 2.....□□, □

1□□=1□/□□−□□,□/
1□□=1□/□□−□□,□/
□ = 1□□=1□□□□
□ = 1□□=1□□□□

The objectives are to maximize the consistency and uniformity by minimizing the overall inconsistency and the overall non-uniformity, respectively. The proposed scheme attempts to achieve these by the use of the fine-grained answers and the guidelines. It would also be of interest to capture the interaction of consistency and uniformity, potentially capturing the variability of across a set of items, which is facilitated by the formulation immediately preceding.

Sample Fine-Grained Answers to Questionnaire Questions

In this article, the EoC evaluation form is considered for use in onsite courses at National University. The questionnaire contains the following 12 questions:

- Instructor was well organized.
- Instructor encouraged student interaction.
- Instructor responded promptly to emails and other questions.
- Method of assigning grades was clear.
- Instructor gave clear explanations.
- Instructor was receptive to questions.
- Instructor was an active participant in this class.
- Instructor encouraged students to think independently.
- Instructor was available for assistance.
- Instructor provided timely feedback on my work.
- I received useful comments on my work.
- Instructor was an effective teacher.

For each of the listed questions, a brief analysis of the question is described and a set of possible fine-grained answers is provided for some of them. These analyses facilitate the development of the guidelines and further fine-grained answers.

Instructor was well organized. This organization has several aspects, namely (a) selection and timely coverage of course content; (b) the delivery of lectures; (c) the class activities; (d) student assessment work (homework, quizzes, exams, discussions, projects, etc.);

(e) development of supplementary material; etc. A possible set of fine-grained answers to this question needs to address each of these different aspects.

Instructor encouraged student interaction. This question has to address the several aspects, such as (a) whether any routine and/or novel activities were designed and used to enhance interactions; (b) whether the interactions facilitated the learning objectives or were they distractive; (c) whether there were measures to assess the effectiveness of the interactions; (d) whether the interactions were natural or imposed; (e) whether the time taken by interactions were of the appropriate level; etc.

Instructor responded promptly to emails and other questions. What is, in the perception of a student, an important or relevant question, may not be so in the bigger picture of the course or its effects on the student's performance in the course. Also, there might be a mismatch between the notion of "promptness" from the students' perspective and the realities for email responses. Thus, the answer to this question has to take into account numerous things, such as (a) the importance, relevance, urgency, and seriousness of the question as it pertains to the course; (b) the definition of a reasonable timeframe for response based on (a) in this list; (c) whether some answers which were deferred for a later time were eventually answered at the required time; etc. As a simple example, a possible set of fine-grained answers to the present question could be the quantification of the levels of timely responses as follows. It must be noted that the percentages given in the context of this and other questions are examples and do not in any way represent the outcomes of any empirical studies.

1. None or hardly any timely responses (< 10%)
2. Timely response given a few times (10–30%)
3. Timely response given some of the time (31–60%)
4. Timely response given most of the time (61–85%)
5. Timely response given all of the time (> 85%)

The timeliness itself needs to be quantified as well. For example, for trivial questions which do not require immediate answer, a reasonable response time could be 24 hours. For questions/queries of moderate importance, a reasonable response time could be 8–12 hours, and for matters of urgency, a reasonable response time could be 1–4 hours. Some examples of what constitutes trivial, moderate importance, urgent, etc., need to be given in the guidelines.

Method of assigning grades was clear. This question has to address the facts whether (a) the instructor had clearly laid out the grading policy and rubrics in the course outline; (b) whether appropriate weightages were given to the different student work based on the difficulties and proportions of time spent by the students; (c) whether grading on a curve was used; etc.

Instructor gave clear explanations. This question has a several aspects such as (a) level of clarity in the explanation given by the instructor (extremely clear; very clear; somewhat clear; not very clear; adds to confusion); (b) consistency in the clarity of the explanations given by the instructor (clear all the time; clear most of the time; clear sometimes; clear very few times; not ever clear); (c) whether a few different approaches were taken to explain the same concept to cater to different backgrounds and learning styles of students; (d) whether different examples and modalities were used in the explanations; etc. Sample fine-grained answers to this question are offered here:

1. Instructor gave fuzzy and confusing explanations
2. Instructor gave explanations which were somewhat clear
3. Instructor gave explanations which were adequately clear
4. Instructor gave clear explanations embellished with example(s)
5. Instructor gave clear explanations in a simple, easily understandable manner embellished with example(s)

Another set of fine-grained answers could be as follows, based on the fraction of times that clear explanations were given.

1. Instructor hardly gave clear explanations (< 10%)
2. Instructor somewhat gave clear explanations (10–30%)
3. Instructor was moderately gave clear explanations (31–60%)
4. Instructor gave clear explanations most of the time (61–85%)
5. Instructor gave clear explanations almost all of the time (> 85%)

Instructor was receptive to questions. This question may be thought of as having two aspects: (a) the level of receptiveness to questions, and (b) the level and quality of response. Based on these, the possible fine-grained answers are given as follows:

1. The instructor ignores or gives tangential or evasive answers
2. The instructor answers questions but makes no attempt to get feedback
3. Answers questions but does not ensure that it has been understood
4. Answers when asked questions, in multiple ways when necessary, and ensures that the answers have been understood
5. Actively seeks questions and answers them, in multiple ways when necessary, and ensures that the answers have been understood

The question may also be interpreted to have the instructor answer questions with the following frequencies:

1. Instructor was never or hardly ever receptive to questions (< 10%)
2. Instructor was somewhat receptive to questions (10–30%)
3. Instructor was moderately receptive to questions (31–60%)
4. Instructor was receptive to questions most of the time (61–85%)
5. Instructor was receptive to questions almost all of the time (> 85%)

Instructor was an active participant in this class. For this question, the activities that an instructor undertakes in a class vary, depending upon the nature of the course. For example, the kinds of activities of an instructor could include, but not be limited to, (a) lecturing; (b) solving problems; (c) demonstrating a physical experiment; (d) showing a computer simulation; (e) leading/moderating onsite class discussion or online chat session; (f) working with students in some in-class activities; etc.

Instructor encouraged students to think independently. The exact types of activities, exercises, tasks, etc., that the instructor designed and implemented depend on the nature of the course. A few possible examples (common across a variety of courses) are (a) posing relevant, interesting questions for the students to solve; (b) giving well-designed, hands-on activities; (c) giving a twist to an already solved problem and having them solve; (d) allowing the students to make a real-world connection to a concept or technique that they already know; etc.

Instructor was available for assistance. This question begs the *following* questions. Does the "assistance" refer to:

a. Instructor's availability during office hours for onsite class?
b. Instructor's timely email response for onsite/online class?
c. Instructor's timely phone assistance for onsite/online class?

It would also include aspects such as (a) whether the times of office hours are convenient; (b) whether there was enough accommodation in terms of setting meeting times outside of regular office hours for working students who could not make it during the regular office hours; (c) whether the instructor was available over the phone when called; (d) how promptly responses to voicemails/emails were given; (e) the pace of assistance—whether it was rushed or adequate time was spent, etc. Another dimension should be noted, namely, the level of effectiveness of the assistance in terms of helping the students or resolving any issues. This also needs to be incorporated in the fine-grained answers to the question. A set of possible fine-grained answers is offered:

1. Instructor was not available or was hardly ever available (< 10%)
2. Instructor was available a few times (10–30%)
3. Instructor was available sometimes (31–60%)
4. Instructor was available most of the time (61–85%)
5. Instructor was available all of the time (> 85%)

Instructor provided timely feedback on my work. A possible set of fine-grained answers could be the following:

1. None (< 25%) of the graded work was given back on time
2. A little (25–50%) of the graded work was given back on time
3. Some (50–70%) of the graded work was given back on time
4. Most (70–90%) of the graded work was given back on time
5. All (> 90%) of the graded work was given back on time

I received useful comments on my work. There are two broad dimensions in the quantification of 'useful comments'—the kinds/extents of comments and the amounts of comments. Based on these, two possible sets of fine-grained answers are offered:

1. None or hardly any, such as just check or cross marks
2. Low. For example, there are indications of where there were errors, and what the correct answers should have been, but with no explanations of why they are the correct answers or how they have been arrived at
3. Moderate amount of comments
4. Somewhat detailed comments
5. Detailed comments which, when followed the next time, would substantially improve the quality of the student work

Based on the percentage of student work that received substantial useful comments, the possible answers could be as follows.

1. None or hardly any of the work (amounting to < 10% of the grade)
2. A little of the work (amounting to 10–30% of the grade)
3. Moderate amount of work (amounting to 31–60% of the grade)

4. Most of the work (amounting to 61–85% of the grade)
5. Almost all of the work (amounting to > 85% of the grade)

Instructor was an effective teacher. This question is too broad to quantify and map to a number between 1 and 5. It could perhaps be derived as a weighted average of numerous questions that pertain to relevant aspects of teaching. If this question is posed even to the instructors, "What constitutes effective teaching and how is it measured?" or "What makes you an effective teacher and how is this evidenced?", there would likely be a whole range of answers. Therefore, this must be laid out on a clearly defined, quantified framework after some study.

Author comment. It should be noted that although each question of the original questionnaire is expanded to a list of about five fine-grained answers, a student need only choose one fine-grained answer to a question, since the fine-grained answers are mutually exclusive. Thus, in a 12-question questionnaire, a student will provide only 12 answers, although choosing from a list of about 60 short, clear, unambiguous, well-quantified "choices." In the current scheme, a student must think of an answer to the question and map it to the number. The burden of "thinking" of the appropriate answer and then "mapping" it to a number in the current scheme is alleviated in the proposed scheme by clearly laying out the choices corresponding to the numerical scores. Thus, the proposed scheme will take no more time than the current scheme.

Benefits of the Proposed Scheme

The major benefits of fine-grained answers and guidelines are described as follows:

1. ***Decreased ambiguity***—they reduce or remove the "fuzziness" in the quantification of the faculty efforts and introduce definiteness. For example, the number of homework, quizzes, exams, projects, etc., that were given out and graded is indicative of the instructor's effort toward the course, so this gives a quantification of the effort that the instructor would have expended for the course. Another example is the level of timely feedback, which is proportional to the instructor's efforts.
2. ***Better understanding of the attributes being measured***—the elaboration and clarification (and in some cases, the quantification) of the questions facilitate better understanding by the students of the attributes being assessed, which in turn, lead to more accurate quantification of attributes being assessed and to the assignment of more accurate numbers to the questions.
3. ***More uniformity in the students' assessments***—in many cases, the fine-grained answers act as implicit guidelines (as applicable), and provide a uniform basis for the students to select more accurate answers corresponding to their experiences. The students will have a better basis for accurately recording the evaluations.
4. ***Removal of inadvertent subjectivity in assessments***—the fine-grained answers and the guidelines provide a definite framework for quantifying the responses, thus minimizing unintended subjectivity and leading to increased objectivity.
5. ***Enhanced verifiability***—for many questions (e.g., posting solutions, handing back graded work, etc.), the answers in the EoC evaluations can be verified against the date/time stamps in the learning management system (LMS). Thus, grossly inaccurate student evaluations can be discarded after proper verification. In fact, several tools can be

easily developed for the automated verification, since the student answers in the EoC evaluations and data against which they are verified are both available electronically.

6. ***Deterrent to biased assessments***—in spite of the fine-grained answers/guidelines, a biased student might still give a lower evaluation. However, the aforementioned notion of verifiability would deter a student from giving arbitrary answers, due to the risk of those answers' being discarded and not taken into account.

Implementation Issues

The major issues in the implementation of the proposed mapping scheme in the EoC evaluation phase are (a) development of well-defined, fine-grained answers to questions, (b) development of unambiguous mappings of the fine-grained answers to numbers, (c) development of a set of simple, easy-to-read guidelines for choosing the right response for a given question, (d) possible revision of the questions in the questionnaire, and (e) pilot trials and iterations to improve and validate the new scheme.

Future Directions

This article provides a theoretical basis for a new kind of end-of-course evaluation questionnaire. It has enumerated several benefits that it offers. Empirical studies provide proof of concept and validity of the hypothesis. The next steps leading to empirical studies are (a) development and refinement of the actual questionnaire, (b) administration of the new questionnaire at the end of actual courses, which will be done in addition to the official end-of-course evaluations, and (c) evaluations of the accuracy and effectiveness of the evaluation results. The appropriate choices of technologies and mechanisms of administration and evaluation need to be studied as well.

Conclusions

Despite over five decades of use of the end-of-course (EoC) evaluations in institutions of higher learning, no single scheme or set of schemes has emerged that are considered fair, objective, and valid. One of the central problems is the lack of mechanisms to accurately map the answers to the questionnaire to numerical quantities (usually on a Likert-type scale). There are no precise guidelines for the "mapping process" available to the students in order for them to precisely determine what number is the most appropriate response for a given question. This leads to non-uniformity and inconsistency in the responses. In this article a scheme is proposed that provides a set of fine-grained answers to each question in the questionnaire (wherever applicable), along with a simple but well-defined set of guidelines for answering the questions. These are expected to improve the uniformity and consistency of the student responses.

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Note to the Author

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Submission deadline. Submissions for the next, 8th issue will be accepted until October 1, 2014. Please email your manuscript to Dr. Peter Serdyukov at pserdyuk@nu.edu.

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Brown, H. (2007). *Principles of language teaching and learning.* White Plains, NY: Pearson Longman.

European University Association. (2010, May 26). A global crisis: New report looks at the effects of the economic recession on European universities. *Education Insider.* Retrieved from http://education-portal.com/articles/A_Global_Crisis_New_Report_Looks_at_the_Effects_of_the_Economic_Recession_on_European_Universities.html

Appendix A (12pt bold)
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Text of appendix in 12pt, full justified, followed by 24pts white space before next appendix or About the Author(s).

About the Author (10pt bold, followed by 12pts white space; all type in this section is also 10pt)

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