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Southwestern Business Administration Journal (SBAJ) Volume 15, Issue 1, 2015 consists of six articles covering a variety of topics in business and pedagogy. Each article underwent a rigorous double blind review process consisting of at least two reviews per article. The final version of each paper appearing in this issue reflects the inclusion of the reviewers' comments. The Editor-in-Chief thanks all the reviewers for the timely submission of their assessments and their assistance in helping enhance the quality of the articles published in SBAJ. The Editor-in-Chief thanks all the authors for their submissions.

The *Southwestern Business Administration Journal (SBAJ)* is a refereed publication. The aim of this journal is to provide a forum for current thoughts, techniques, theories, issues, trends, and innovations in teaching and learning within the business administration field. Its general focus is to enhance the teaching and learning process. The SBAJ is published in spring and fall of every year. All manuscripts submitted to the journal will be subject to a double-blind referee process.

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EFFECTIVE TEACHER CREATES AN ATMOSPHERE FOR STUDENTS' ACHIEVEMENT: AN EXPLORATORY CONCEPT

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ABSTRACT

Effective teaching stimulates critical and independent thinking skills, promotes growth, and motivates students' creativity. Pedagogical expertise can be applied to a diverse group of students, from beginning students to those requiring developmental support, and even to those who have acquired considerable academic sophistication. Creation of a positive classroom atmosphere stimulates growth and encourages success. Therefore, it is fulfilling for a teacher to use his or her mind in quest for knowledge while sharing the knowledge with the students being taught. The environment the teacher creates will arouse curiosity, stimulate thoughts, enhance interest, and create interaction that will foster students' learning and, ultimately, lead to success. Effective teachers maintain a supportive learning environment, stimulate student interest, and effectively monitor and foster student progress. However, some regulatory activities limit the teacher's commitment, intensity, and perfectionism. This paper explores the impact of effective teaching on students' behavior and achievement.

Keywords: Exploratory, effective teaching, stimulation of interest, commitment to care, cooperative learning effective assessment of student.

INTRODUCTION

According to Oxford English Dictionary, teaching is showing the way, directing, guiding and imparting knowledge; therefore, teachers in the classrooms play important roles as facilitators to provide effective classroom instructions. Although some people are natural teachers while others are not, all teachers can improve their teaching skills if they are well informed about teaching and learn best practices. Teaching is an interactive process between teachers and students, providing the opportunity for students to learn. In every institution there are people who teach while others learn. Teaching is not restricted to those with college degrees and professional teaching certification. Whenever learners and teachers congregate some teaching occurs.

One important aspect of effective teaching is the ability to create a positive classroom atmosphere. An effective teacher is expected to know the subject being taught, to consider what the students know, to clearly communicate to the students, and to stimulate their curiosity to learn. By achieving this, the teacher can maintain better classroom management and discipline. On the flip side, some argue that 'bad teaching' is also considered an effective teaching since it forces students to study on their own and be independent of the teacher. The responsibility for effective teaching lies not only with the teacher but with the students as well.

Effective teaching becomes successful teaching if the teacher creates positive feelings about the course, arouses curiosity, and stimulates thought and interest of the students to learn what the teacher intends to teach. Effective teachers are distinguished by their dedication to the students and to the job of teaching, believing that all students can learn, although differently. Rubio (2010) emphasized that teachers strive to motivate and engage all their students in learning rather than simply accept that some students cannot be engaged and are destined to do poorly. Creating a positive learning environment can promote, encourage and enhance students' ability to learn and achieve success.

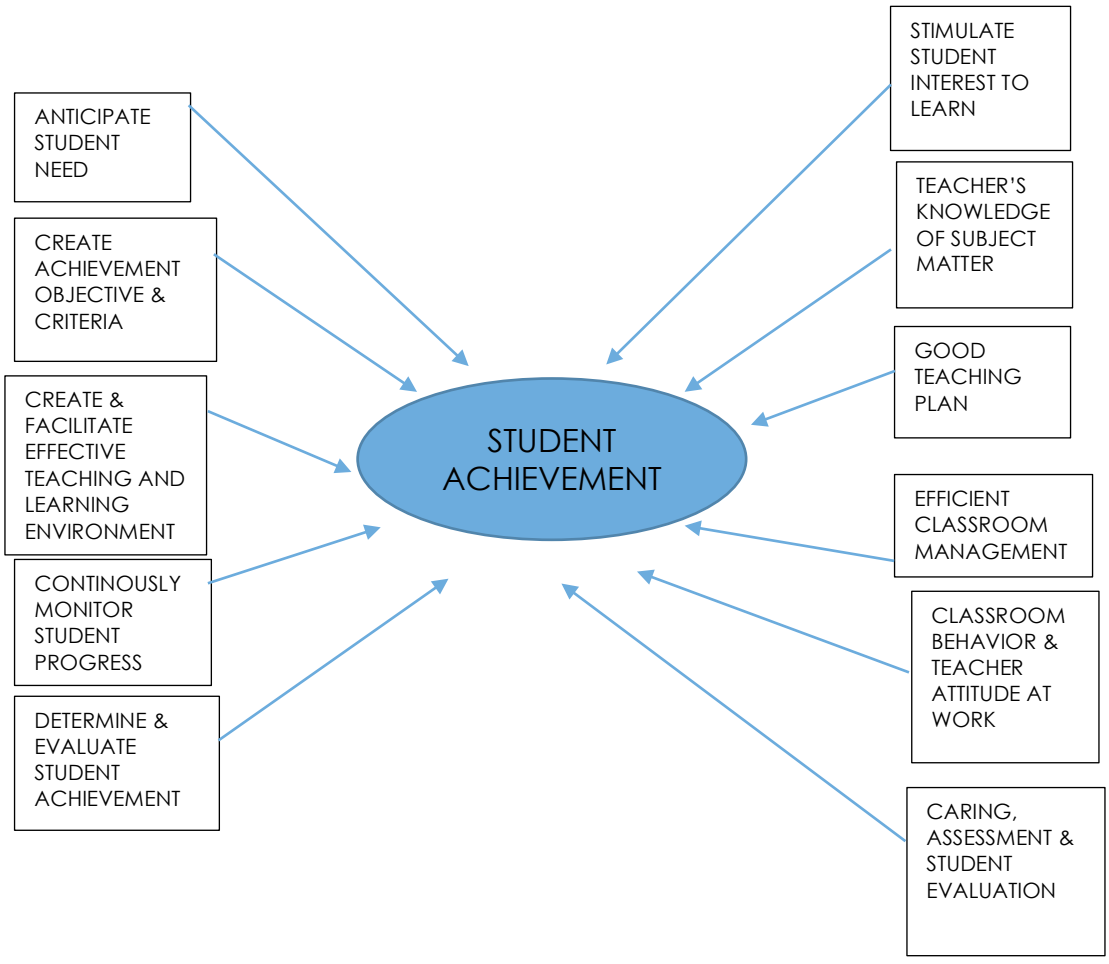
According to Fraser & Pickett (2010), the classroom learning environment involves many relationships that exist between the teacher and students and among students. Indeed, effective teachers do not merely stand in front of the class demonstrating the extent of knowledge of subject content, but also teach to promote and enhance learning.

Effective teachers are characterized by the ability to manage themselves and their students. To be effective, teachers must demonstrate personal and professional skills and a focus on student achievement. Alton-Lee (2003) argues for an effective link between the school and the culture. In addition to being caring and meticulous about assessment, feedback and evaluation, both the school and the culture must take responsibility for the students' learning processes, the curriculum goals, and the academic and social maturation of the students.

METHODOLOGY

The scope of this paper is limited to published reviews of relevant literature on teaching and to 20+ years of professional University teaching experience. The study is classified in two phases: it structures the concept of student achievement as a goal and identifies some achievement objectives and some pertinent attributes of an effective teacher. The structure is organized by placing the goal at the center, achievement objectives on the left, and pertinent attributes of an effective teacher on the right hand side. The identified achievement objectives are: 1) Anticipation of student needs. 2) Setting achievement objective and criteria. 3) Creating teaching and learning environment. 4) Continuous monitoring of student progress. 5) Determining and evaluating student achievement.

Some selected attributes in order of importance based on students' perception are: 1) Stimulating student interest. 2) Teacher's knowledge of subject. 3) Good teaching plan. 4) Efficient classroom management. 5) Classroom behavior and teacher attitude at work. 6) Caring, assessment and student evaluation.



Giving the ways students are taught in the traditional manner, and the levels of overall performance in recent years, it is reasonable to explore the aforesaid achievements and attributes that may impact students learning and teaching effectiveness. Suffice it to say there is no single way or method to solve the ineffective or inappropriate teaching styles of an instructor or the lack of classroom engagement and motivation.

LITERATURE REVIEW

Stimulate Interest for Learning

The diversity in today's classroom allows for cultural differences as well as differing student types. Therefore it is imperative for teachers to accommodate different learning styles to create positive feelings about the course being taught while creating a conducive learning environment. Brown and Atkins (2002) argued that a lecture may change students' perceptions of a problem or theory, increase the students' insight, and may stimulate the student to read, think, and discuss ideas with other students. However, probability of these events is dependent upon the students' knowledge, attitudes, and motivation to learn and on the teachers' preparation, lecture structure, and presentation.

According to Rubio (2010) motivating students encourages them to be more receptive and excited about the subject, be aware of the value and importance of learning, and have a better attitude to learn. Effective teachers makes students increase their academic self-concept, their interest in the subject and their desire to learn more, and to achieve at a high level. Capturing students' interest and getting students engaged are critical to successful teaching and learning. Research on the dimensions of college teaching has shown that stimulating students' interest in the content of the course is the most powerful predictor of the overall ratings of the teacher, and the fourth most powerful predictor of student achievement.

Ferguson (2011) postulated that a teacher's natural voice sometimes can influence students' perception of the teachers' competence and warmth. Individuals with attractive voices that vary in sound, tone, and emotions hold the attention of students, thereby appearing to stimulate student learning. Loud voices can appear more authoritarian and knowledgeable than soft voices.

He also claimed that extroverted instructors who use more body gestures and expressive language are perceived by students as enthusiastic about the course. The instructors' strong interest in the course ignites in students a similar enthusiasm that leaves them with the perception that they learned more from the course. The students perceive warmth and friendliness in the teacher when they can freely approach and have personalized interaction for guidance in their academic program. Accessibility out of class can also alter the ratings of a conscientious teacher.

From a motivational standpoint, it is important to remember that students may not enter the class with prior knowledge of or appreciation for the subject.

Instead, they may enter with some anxiety about their skills or performance, with a degree of resistance or with a predetermined, negative attitude. Indeed, the ideas the teacher finds stimulating may be at a level above students' understanding. As a result the teacher finds that while enthusiasm for the subject is motivating, students can become discouraged if what the teacher values is not apparent to them. (Theall, M., 2004).

Since several factors, such as competence needed for new employment intellectual curiosity, degree requirements, etc., motivate students, it is impossible for the teacher to incorporate all techniques of motivation. However, it is important that the teacher possess appropriate skills to motivate students. Students' interest can be triggered by certain environmental factors such as teacher behavior. Students who experience heightened emotional interest are pulled toward a subject because they are energized, excited, and emotionally engaged by the material. Teachers' clarity in expression or proficient and effective communication style can increase cognitive interest because they make information more organized and/or comprehensible for students. This increase in emotional arousal heightens attention and make it easier for students to encode more information (Menzer, J., 2012).

Cooperative learning also stimulates students' interest to learn and is regarded as an effective instructional practice that improves students' understanding of subjects. Cooperative learning activities such as round robin, team-pair-solo and jigsaw arouse student curiosity, and encourage independent thinking, self-esteem and stimulate participation.

These activities not only help the individual student in a group to learn, but also help a group members to learn. Stahl R. J. (nd) argued that all "jigsaw" activities are not cooperative learning jigsaw activities and that, students work in small groups does not mean they are cooperating to ensure their own learning and the learning of others in their group.

A good strategy can encourage students to strive to reach their individual best. Gardner (1999), in his explanation of the theory of multiple intelligences (MI), indicated that all individuals possess several independent intelligences. The intelligences he specified are: linguistic, logical, mathematical, musical, spatial, bodily-kinesthetic, interpersonal, intrapersonal and naturalist. He stipulated that, no two individuals' not even identical twins or clones, have exactly the same amalgam of intelligences, the same strengths and weaknesses. Where individuals differ is in the strength of these intelligences and in the ways in which such intelligences are invoked and combined to carry out different tasks, solve diverse problems, and progress in various domains.

Gardner (1999) further confirmed that the use of multiple intelligence (MI) enhances the learning process. Campbell et al. (2004) stress the importance of encouraging students to explore and use all the intelligences.

Knowledge of Subject Matter

There are different kinds of teachers. Some talk without engaging the encouraging students to explore and use all the intelligences. encouraging students to explore and use all the intelligences. Students, some are dictators, while others teach topics not relevant to subject matter and at the end of the class period student find themselves not knowing what was discussed in class. Pascarella and Terenzini (2005), found that students become more critical, reflective, and sophisticated thinkers during their college years, and that college significantly enhances their general intellectual and analytical skills, critical thinking, and intellectual flexibility.

They concluded that students make significant gains in subject matter knowledge, verbal and quantitative skills, and oral and written communication during the undergraduate years. According to the McBer Report (DFES, 2000), students expect a teacher to have good content knowledge to be considered effective, which inspires the students' confidence in the teacher Rubio (2010).

In 1986, Shulman introduced the phrase "*pedagogical content knowledge*" which in his view was the key to distinguishing the knowledge base of teaching; this rested at the intersection of content and pedagogy. Pedagogical content knowledge is defined as teachers' interpretations and transformations of subject-matter knowledge aimed at facilitating student learning and enhancing student interest.

Then in 1987 he stipulated that, to teach students according to present day standards, teachers need to understand subject matter deeply and flexibly to help students create useful cognitive maps, relate one idea to another, and address misconceptions; and teachers also need to see how ideas connect across fields to everyday life. Finally, he concluded that understanding subject matter provides a foundation for pedagogical content knowledge that enables teachers to make ideas accessible to others.

He proposed several key elements of pedagogical content knowledge:

1) knowledge of representations of subject matter (content knowledge);
2) understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter; and
3) general pedagogical knowledge.

However, Shulman went further to include curriculum knowledge, knowledge of educational context, and knowledge of the purposes of education as part of the knowledge base for teaching (Shulman, 1987). Solís (2009) affirms that, when teaching subject matter, teachers' actions are determined to a large extent by the depth of their pedagogical content knowledge, making this an essential

component of their ongoing learning. Pedagogical content knowledge, in fact, is essential to effective content teaching. To improve teaching and learning quality in critical content areas, teachers need to resist some old traditions in professional learning and, instead, acknowledge and expand the insights of experts who develop competence in subject matter teaching.

Having good knowledge of subject matter is an important aspect of good teaching, as it strengthens the teacher's confidence to challenge student's misconceptions and heightens the teacher's moral. Ferguson & Womack (1993), stipulate that "effective communication of subject matter content is an essential aspect of good teaching.

Good Planning

Kyriacou & Sutcliffe (1978b) describe teaching as a stressful profession; Milstein & Golaszewski (1985), therefore, consider planning as an integral part of effective and successful teaching. It simplifies the teaching process and enables teachers to effectively and efficiently impart knowledge to students. Cruickshenk & Haefele (2001) stated that "effective teachers are able to qualitatively do more with the same amount of time" hence, good planning is critical to classroom management and organization, and to achieving learning.

Good planning entails a comprehensive approach from course description/objectives to student performance evaluation. Good lesson plans stimulate students' interest and encourage participation. To simplify the teaching process, it is essential to make lesson plans that reflect the teachers' creative and unique ability to transfer facts and relevant materials to students efficiently. According to Gurney (2007), when teachers show enthusiasm, and it encourages interaction in the classroom, the work of learning turns into pleasure. Also, Stronge et al. (2004) emphasized that, teachers who are enthusiastic about their subjects and learning, motivate students, and therefore increase achievement. Although good planning includes documents such as course syllabi/outlines, the extent of these documents depends on the institution's goals but the lesson plan give the teacher some room for flexibility in techniques and strategies.

Classroom Management

Since effective use of school time begins with efficient classroom organization and management, it is important for teachers to devise strategies to maintain focus on instruction in real time. As specified by Master Instructional Strategy (nd) teaching takes time and managing classroom time is a challenge and that it is about procedures becoming routines. Routines give structure to the instructional environment therefore, classroom management is not imposing strict and rigid rules.

Good classroom management include: lectures coverage, information, explanation, and motivation. It is to: 1) Make course objective clear and manage class time. 2) Create positive and supportive learning environment. 3) Facilitate learning, anticipate students´ needs. 4) Effectively assess student learning,

well-prepared for class, usage of criterion based grading to evaluate each student independently of other students. 5) Implement outcome base assessment to promote students motivation, enthusiasm and learning.

Effective teachers use few classroom rules, and more routines to maintain a relaxed and warm environment to enhance learning. McLeod et al. (2003) stated that it was more effective and efficient to use routines instead of rules in the classroom. Achievement increases when a positive productive learning environment exists. Stronge et al. (2003) posit that effective teachers use more routines for daily tasks than rules. Studies have shown that when students know exactly what is expected of them in specific situations, behaviors tend to be appropriate. According to Wong and Wong (2005), efficient and workable procedures allow many activities to take place with minimum confusion and wasted time while procedures help teachers to structure and organize a classroom for maximum engaged learning time.

Students readily accept a uniform set of classroom procedures because it simplifies their task in succeeding in school. However, flexibility and adjustment to classroom policies also provides for students' success. The greatest part of the loss of classroom instructional time is attributable to discipline problems.

According to Blasé (1982), teachers complained about having to cope with student disregard for classroom and school rules which resulted in student misbehavior that interfered with the teaching processes and student performance. In order to provide high-quality instruction, it is imperative for educators to understand how students learn. Wong and Wong (2005) distinguished between disciplines and classroom management, stipulating that: "effective teachers manage their classrooms with procedures and routines. Ineffective teachers discipline their classrooms with threats and punishments." They further specified that discipline has to do with how students behave, and management has to do with procedures on how students have to work in the classroom.

Arguably, knowing the students' preferences for learning helps to solidify the appropriate manner for successful implementation. Instruction and interventions which match students' strengths to targeted deficit areas appear to show favorable results in student performance. Master Instructional Strategy (MIS) (nd).

Classroom Behavior and Teachers' Attitude towards Work

Teachers' attitudes towards work can either encourage or discourage students from learning. Indeed teachers are facilitators of lifelong learning and are regarded as role models to lead and guide students through success in their educational journey. A teacher with a burning desire for teaching should communicate this desire to the student. According to Kreitner & Kinicki (2007), job satisfaction reflects the extent to which people like their jobs. As expected, teachers' working conditions, assessed by their level of job satisfaction, affect teacher-student interaction; hence, higher levels of job satisfaction improve teachers' morale, which students perceive positively (Ahmad and Sahak, 2009).

Students perceive a teacher's non-verbal signals from the minute he/she steps into the classroom. Therefore, exhibiting good attitude and pleasant personality such as cheerfulness, openness, understanding, honesty and empathy could be considered an asset to the teacher and ease the learning task of the students.

Caring, Assessment and Student Evaluation

Effective teachers have compassion and caring, and strive to bring the best out of their students by: 1) giving them positive reinforcement when possible, 2) creating opportunities to discuss outside experiences, 3) providing opportunities for flexibility, 4) considering students' personal problems when appropriate, 5) allowing for individual differences, and 6) developing a supportive environment and being sensitive to their learning barriers. Stronge et al; (2004) stated that students perceive effectiveness when teachers show kindness, gentleness, and encouragement. Effective teachers, therefore, demonstrate genuine concern and empathy through understanding students´ concerns and questions.

Gurney (2007), argued that learning should be considered an emotional exercise which allows students to get engaged, as it appeals to their emotions. Since caring has moral, social, and personal facets, the proper balance of all facets nurtures individuals and facilitates the process of learning. A key facet of welcoming encompasses connecting new students with peers and adults who can provide social support and advocacy. Efforts to create a caring classroom climate encourages cooperative learning, peer tutoring, mentoring, advocacy, peer counseling and mediation, human relations, and conflict resolution (UCLA, n.d.).

According to Pascarella and Terenzini (2005), college environments that emphasize close relationships and high levels of student-faculty contact promote critical thinking, analytic competencies, and general intellectual development. Interaction between the student and teacher becomes important for a successful relationship through the students' academic journey. Continued relationship between teachers and students results in an increased cohort retention and graduation rate. It is believed that a close but limited relationship between the student and teacher can be very helpful in developing students' self-esteem and confidence. The teachers indirectly, feel satisfied with their job while students feel satisfied that they have learned. Respect between teacher and student should exist, with both feeling enthusiastic when learning and teaching occur. Having established a positive relationship with students, teachers will encourage students to seek education, be enthusiastic, and to be in school (Ahmad and Sahak, 2009).

Every student is capable of achieving success; therefore, effective assessment of student learning is of vital importance and viewed as an effective learning process. Students' performance assessment is a difficult component of effective and efficient teaching, and might be considered a serious and often tragic enterprise. Ramsden (1992) asserts that assessment is a process of critical importance in defining student approach to learning. Oliver (2004) stated that assessment plays a prominent role in influencing what students learn and the scope and extent of their learning. Assessment is also a tool for teachers to better

understand exactly what students know and do not know (Biggs, 1999). Although not statistically proven, faculty self-evaluation is an instrument teachers sometimes embrace to seek the honest opinion of their students to improve their teaching and to know the students' perception of the teacher. Gurney (2007) pointed out that, in order to improve own knowledge, methodology and learning environment, teachers should allow students to give their feedback. Although student perceptions of the teacher are sometimes based on personal feelings instead of objective evaluation, the continued use of this form of evaluation enables the teacher to determine if there are persistent characteristics that need attention

The process of continuous improvement, for example, enables students to improve on their work if previous work did not meet the standard expectation and learning outcome of the course. While providing students with appropriate feedback and assigning final grades on the course may not be an important end of the course for the teacher, it is held in utmost importance by students. Examinations are not always true tests of knowledge; therefore, criteria based evaluation models should be used to evaluate students independently, i.e., evaluate each student based on the completion of the objective of the course instead of judging comparatively. For the purpose of accurate record keeping and documentation, teachers must endeavor to establish firm grading and assessing criteria that include numerical grade factors weighted in relation to the teacher's evaluation plan.

CONCERNS AND THOUGHT FOR FUTURE RESEARCH

There are several limitations of this study. The paper explores the impact of effective teaching on students' behavior and achievement, however, it is sometimes difficult to motivate every student in the classroom as some students seem to take their education lightly. Although the paper proves strong validity in content, based on the literature review, evidently, research on such topics has been conducted and it is possible that some other researchers have come up with similar thoughts. Different approaches can be taken to motivate students and the approach taken might depend on the teachers' personal and professional skills.

Considering the diversity in today's classroom, cultural differences and differing student types, a number of future potential research areas can be recognized to achieve an integral examination of effective teaching. In fact, the quantification and assessment of each objective and attributes might be an important and demanding task that probably has never been attempted. However, my study adds to earlier research that adopted similar concepts. As each attributes of effective teaching become more prevalent in students' lives, it is necessary to conduct a study that examines all aspects of effective teaching not limited to those covered in this paper. This paper has opened the door for further studies to be conducted and to investigate more on the impact of effective teaching on students' behavior and achievement.

CONCLUSION AND THOUGHTS

Effective teaching is daunting and complex. The effective teacher must know the subject matter, stimulate student interest, create and maintain a dynamic and supportive learning environment, effectively monitor and encourage student progress and success.

It is difficult to motivate every student in the classroom as some students seem to take their education lightly. An effective teacher should combine care with professionalism believing that motivated activities can help the teacher develop a positive relationship with students. The result of this positive relationship will ultimately encourage teachers to become more motivated to engage in learning activities (Birch & Ladd, 1997; Ladd & Coleman, 1997). An effective teacher could identify the factors that cause students to perform as they do and propose ways to eliminate the performance gap between current performance and the performance target. The teacher could also ask students to list a manageable number of possible causes of his/her their problems. This will give the teacher a template to guide students to success. If all efforts fail, students can be sent to the college or university's Students Support Services (sometimes called the TRIO program) where can receive further assistance such as: academic advising, counseling, career exploration, motivation seminars and peer mentoring that will help them excel through college.

There are significant differences between beginning and experienced teachers, the most prevalent of which is that new teachers seem to approach the classroom with a personal belief of what teaching is all about and therefore do not focus on students' learning objectives. Instead, they focus only on their knowledge of the subject. However, an experienced and effective teacher tends to set achievement goals at the beginning of the semester and works through the set goals.

Despite these differences, however, it is important to know that the more years of classroom teaching, the more confident teachers become in the overall performance, assessment and evaluation of their students.

In the learning community, every member is a learner, and may also play some role as a teacher. Learning is neither limited to what is formally taught nor the time spent in classrooms. It occurs whenever and wherever the learner interacts with the surrounding environment. Therefore, in every institution there are people who teach while others learn. Teaching is not restricted to those with college degrees and professional teaching certification. Indeed, wherever leaners and teachers congregate some teaching and learning takes place.

Giving the ways students are taught in the traditional manner, and the levels of overall performance in recent years, it is reasonable to explore the aforesaid achievements and attributes that may impact students learning and teaching effectiveness. Suffice to say there is no one single way or method to solve the inefficiencies and ineffective or inappropriate teaching styles of an instructor and

on the part of the students, the lack of classroom engagement and motivation. It can therefore be concluded that teachers who have the capabilities to inspire and motivate students to thrive are effective teachers.

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AN EVALUATION OF TECHNOLOGY FOR STUDENT ENGAGEMENT

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ABSTRACT

Today's tech-savvy students use technology in almost everything they do. However, today's teachers are not as likely to fall into a category of being "tech savvy" and may need instruction on best practices. The purpose of this paper is to discuss the use of three online programs, Poll Everywhere, Plickers, and Geddit, and their uses in classroom settings. This article will also present tips for improving the learning experience using these tools. The significance of utilizing technology in the classroom is to promote student engagement in the lesson and utilize an informal assessment approach for teachers to check the understanding levels of their students. Due to the fast paced advancements in technology, the three online programs chosen seemed the easiest fit for teachers regardless of technological skill. With all of the options available to teachers and students, reliable technology for student engagement is a must have for the 21st century teacher to utilize to ensure critical thinking and comprehension of concepts.

Keywords: teaching with technology, pedagogy, critical thinking, student engagement, comprehension checks, feedback, formative assessment

Today's tech-savvy students use technology in almost everything they do. Because students are accustomed to constant interaction from texting, posting on Facebook, and sending images through SnapChat, it is hard to maintain attention and engage the students in the classroom using traditional teaching methods. One solution may be for instructors to find innovative methods to engage these students using the same technology that they may enjoy in their personal lives.

These students are likely to be considered "digital natives", a term that was first used by Marc Prensky (2001) to explain how today's students are different. He stated that students have read less and have spent a large amount of time gaming on the internet. Prensky continued to describe this concept of digital natives as being accustomed to having access to instant information. He explained that, "They like to parallel process and multi-task. They prefer their graphics before their text rather than the opposite, and they prefer random access (like hypertext). In addition, digital natives function best when networked and thrive on instant gratification and frequent rewards. They prefer games to 'serious' work." (para. 11). Because today's students likely exemplify this type of behavior, engaging these same students in traditional learning methods may be challenging. The findings of Snyder and Snyder (2008) further explained that, "traditional instructional methods use too many facts and not enough conceptualization; too much memorizing and not enough thinking. Therefore, lecture and rote memorization do not promote critical thinking" (p. 92). Based on these premises, today's instructors may need to update their teaching strategies.

Assuming current students are likely to be digital natives, these students would expect changes in the way material is presented in classrooms. However, the traditional method of teaching may leave some disconnect. With changes in student learning, comes changes to the classroom where student learn because information technology has reached a turning point that may differ from the way traditional teachers and administrators may view teaching methods. Now, the use of technology in teaching has reached the mainstream teaching community (Grajek, 2015). Current teaching methods using older technology often fail to facilitate the learning process; in this case older technology that may be only a few years old. It is imperative for instructors and administrators to look at how technology can be used in the classroom for student engagement using informal assessment and comprehension checks across the K-12 and postsecondary classrooms. This review also means that teachers must "…think of their students not as receivers of information, but as users of information. Learning environments that actively engage students in the investigation of information and the application of knowledge will promote students' critical thinking skills (Snyder & Snyder, 2008). If used effectively, technology can help to promote engagement and an increase in critical thinking abilities, which is often the goal of educational institutions.

Unfortunately, today's teachers are not as likely to fall into a category of being digital natives and may need instruction on the best practices and programs to engage students. According to the U. S. Department of Education (2013), the

average age of teachers across the U.S. in the 2011-2012 school years was 42.6 years, and only 15.5% of these same teachers were under the age of 30. These instructors were probably taught using traditional methods, which likely did not use technology, and they probably did not learn how to effectively use technology in their teacher preparation programs. Teachers may have little experience or training in using new technologies, so many teachers are likely to be uncomfortable using it in the classroom (Koehler, Mishra & Cain, 2013). If one is uncomfortable using a technology, he or she is unlikely to use it.

Training on the effective use of technology is essential, and, according to Grajek (2015), "Hiring and retaining qualified staff, and updating the knowledge and skills of existing technology staff" (para. 2), has an important effect on the technology used in the classroom that could possibly engage students in increased learning. She continued, "Optimizing the use of technology in teaching and learning in collaboration with academic leadership, including understanding the appropriate level of technology to use" (para. 2), could be the deciding factor in whether a teacher makes an impact on the students' learning outcome. Using technology does not automatically result in learning; if a teacher does not effectively use the technology available, students are less likely to learn the material presented because the teacher may spend too much time on managing the technology.

It is likely that educators may find it difficult to connect with students' preferences to learning because they are so busy focused on what to know and how to use it. Snyder and Snyder (2008) stated, "To link critical thinking skills to content, the instructional focus should be on the process of learning" (p. 91). Spending time ineffectively implementing the technology in class should not interfere or distract for actual learning in the classroom. If the technology is misused, it can be distracting to the learning environment. Even if technology is available, the main goal should always be learning.

For the teachers that have embraced technology in the classroom, there are still several hurdles that must be overcome in regards to professional development, outdated versions of software, compatibility of programs with hardware, and access to digital devices for every student (Donahoo, 2012). Teachers must be trained to use the software effectively, the most recent updates must be available for use, schools must have the proper hardware, and each student must have access to the technology. In addition to the issue of constantly-advancing technology, K-12 schools must attempt to align with the different technology used in post-secondary environments (distance education, online classes, etc.), using technology effectively in the classroom is a topic that is important for all levels of education.

When properly implemented and supported, technology can empower and excite students and teachers (Cradler & Bridgforth, 2005). Technology skills are often taught to children based on international, national, or state performance

Indicators for utilizing technology to develop an understanding of curriculum concepts. Specifically in Texas, these standards begin at the Kindergarten level and proceed through senior year of high school in what is called the Texas Essential Knowledge and Skills (TEKS) for Technology Applications. While these TEKS are specifically for Technology Applications, these standards can be applied to all subject areas because they integrate learning skills with the use of technology and concepts. Stated in Chapter 126 of the elementary, middle school, and High School Technology Application TEKS,

> The technology applications curriculum has six strands based on the National Educational Technology Standards for Students (NETS•S) and performance indicators developed by the International Society for Technology in Education (ISTE): creativity and innovation; communication and collaboration; research and information fluency; critical thinking, problem solving, and decision making; digital citizenship; and technology operations and concepts (Texas Education Agency, 2015, para. 1).

Given that students are required to utilize technology in K-12 classes and likely to use technology in their lives, it is also important to use technology effectively at all learning levels. Wynn (2013) stressed the importance of using these technologies effectively when teaching students that are entering colleges and universities. Kohler, Mishra & Cain (2013) acknowledged that integrating technology can be challenging when trying to find a good fit for the classroom, but they state, "integration efforts should be creatively designed or structured for particular subject matter ideas in specific classroom contexts" (p. 14). In other words, instructors should be adaptable to find what works in each unique classroom environment because there is not a universal tool when applying technology.

There are an abundance of new technology programs to use in teaching, but not all of these may be relevant to a particular class, subject, or educator. Each new program, and its subsequent updates, should be tested before being used in a classroom setting, and one should remember that what works for one class may not work for another.

The purpose of this paper is to discuss the use of three online programs, Poll Everywhere, Plickers, and Geddit, and their uses in classroom settings. These three online programs were chosen for review due to the ease of access of creating accounts, ease of accessibility by students, and ease of use with various forms of digital devices. In addition, tips for instructors in using these programs will be presented.

BACKGROUND INFORMATION

Kindsvatter, Wilen, and Ishler (1996) discussed a formal definition of teaching pedagogy as a rational approach to teaching concepts. Pedagogy

encompasses all activities used to aid in learning and can be used to "convey the ideal of enlightened teaching" (p. 6). Using the knowledge gathered during feedback, the instructor can use data gathered to inform their own teaching and, in effect, improve learning. This concept of pedagogy applies to both traditional teaching methods and new methods using technology. Research presented by Hepplestone, Holden, Irwin, Parkin, and Thorpe (2011), shows "A growing number of studies support the hypothesis that technology has the potential to enhance student engagement with feedback, suggesting that changing the process by which feedback is made available to students can enhance student engagement with feedback" (p. 123). In addition, Kindsvatter, Wilen, and Ishler (1996) support the idea that "using a variety of methods increases the probability that student interest will be maintained and the higher achievement gains be made" (p. 236). Adding technology to classroom learning will aid by adding variety to pedagogical methods and, hopefully, better learning.

Feedback on student academic performance has become an important feature of effective and efficient instruction and has been shown to enhance and strengthen student learning (Sadler, 2010). By incorporating instant student feedback within the lesson being taught, students are able to self assess and focus on specific areas in order to improve their own academic performance. One of the easiest forms of instant feedback for students may be the use of technology in the classroom. Technology has become an integral part of society, and as such, can make an important impact in today's classroom. Hepplestone et al (2011) constructed a review of literature in regards to using technology to encourage student engagement with feedback and determined that, "we realize that day-to-day effective assessment and feedback practice is rarely reported in the literature" (p. 124). In this statement, it is believed by the authors that more teachers should be reporting their uses of technology and how it is impacting student learning.

The importance of giving and obtaining student feedback is a constant area of need for teachers. Johnson (2012) determined that "…in order to aid students in using feedback more productively, the transmission model of feedback, where the teacher passes on information to the student, needs to be replaced with a more active and dialogic model of feedback" (p. 72). Utilizing the various technological programs available to teachers, a more active and dialogic model of feedback can be accomplished with technology. Using instant feedback to students with feedback from the technology can be available to teachers to adjust classroom activities as needed.

Using technology in learning can also aid in the collection of formative assessment. Moss and Brookhart (2009) described formative assessment as "an active and intentional learning process that partners the teacher and the students to continuously and systematically gather evidence of learning with the express goal of improving student achievement" (p. 6). They stated that it makes teaching better and engages students. The use of technology can be a valuable tool toward a formative assessment, or formative evaluation, program. Often viewed

as an informal process, the instructor uses these shorter assessment tools using technology at "opportune times to provide feedback to the teacher and students regarding achievement" (Kindsvatter, Wilen, & Ishler, 1996, p. 349). In this case, the use of technology is used as a diagnostic tool for learning and evaluates whether re-teaching is necessary. Because formative assessment occurs during learning, rather than at the end, it can improve learning and achievement because it shows what specific methods work better for learning (Moss & Brookhart, 2009).

RESEARCH METHOD

Teachers have many resources to implement in classrooms. One Facebook page titled "Free Technology for Teachers" provides daily updates of various programs that could be beneficial in certain classrooms. Three links provided on the site led to Poll Everywhere, Plickers, and Geddit, which are utilized in various classrooms and are provided in this article. Using action research, the sites were tested in two classrooms, one at the secondary level and one at the undergraduate level. The instructors in these classrooms used the programs during several days of instruction, and then verbally assessed the students' perceptions of how these tools helped with engagement in the classroom environment.

The use of action research as a research method is seen as a practical application to studying any issue. It is a research design that allows educators to use their own personal experiences for reflection and improvement of practices in specific settings (Creswell, 2002; Phelps & Graham, 2010). Action research is ideal for many situations including educational institutions. The emphasis on action research should be on increasing the effectiveness of one's own work (Hansen & Brady, 2011); in the case of an educational institution, action research is used to help teachers be more effective. When conducting action research, the instructor studies one's own classroom; in effect, the teacher also acts as the researcher (Schwalbach, 2003). Because of its adaptable data collection techniques, teachers can adapt their study to how it best fits what they want to study. Using the results from their study, teachers can choose the most effective lessons to fit their unique situations (McLean, 1995).

Action research is used to enhance teaching because it allows the teacher to experiment with different methods, and ultimately choose that method that best enhances learning (Schwalbach, 2003). According to Creswell (2002), action research "is not undertaken to advance knowledge for knowledge's sake, but for an immediate, applied goal" (p. 614). Using action research, the study is used to immediately benefit the educational process (Creswell, 2002; Schwalbach, 2003) and is used to improve both current and future lessons.

Action research was chosen as the research procedure because it was practical for the learning environment and allowed instant feedback on learning. In addition to learning how the technology functioned, it allowed the researchers to ask questions and receive feedback during the actual lesson using an

information evaluation process. Asking informal feedback during the lessons allowed instant feedback so that adjustments could be made instantaneously, as needed.

In this study, the instructors tested each of three technologies during actual lessons in the classroom. Students were asked during the lesson how they were using the technology and what problems they encountered. Verbal assessment during the lesson allowed for the needed feedback instantly and reduced the chance of the student not remembering what actually occurred. Students could also help each other on how to use the technology from the user-view, which may be different than what the instructor was able to see. This method of student interaction also helped to reduce apprehension of both students and teachers to using a new technology tool. At the end of the lesson, students were again asked how they liked the technology overall.

FINDINGS

Based on observations in the classroom, including verbal feedback provided by students, the following information was gathered on three types of student engagement that were used to enhance student engagement and check for understanding.

PollEverywhere

PollEverywhere allows an educator to create a free account to ask questions to students in a class. Using PollEverywhere, the instructor asks the audience a question by projecting it on the screen, then the students answer in real time by using their cell phones through text, Twitter, or other web applications. To respond to the question, the students use their cell phones to send a numerical response that corresponds to the true/false or multiple choice answers. Students type in a response for a fill-in-the blank question. Instructions to respond to the poll are displayed on the screen when the question is displayed. As the students respond to the questions, responses are tallied and displayed on the screen. These responses can be downloaded to a PowerPoint presentation. In the fill-in-the-blank questions, students type in a response that can be displayed as a list or a wordle (word cloud). An instructor is limited to 40 responses per question, but questions can be copied to another poll to create new polls for additional classes (polleverywhere.com, n.d.).

Some of the main advantages of Poll Everywhere include free access, ease of use, and instantaneous feedback. Basic features are free to use, but instructors have the ability to pay a fee for added features. Signing up for an account takes only a few minutes, and one needs only to provide an email account for access. Questions can be generated in the system in minutes so that they can be used immediately or saved for later. The questions can then be displayed as students send their answers in a text message. There is no delay as students send their messages, and the cumulative answers update on the screen as they are sent.

In addition, the answers are tallied as they are received. The amount of time between asking the question and receiving an answer is approximately the same as asking and answering the question orally in class. This process also allows anonymity because the responses are not identified as being from a specific respondent. This may allow more accurate responses, especially if the question is one of student perception.

Poll Everywhere also has its disadvantages, too, which include data entry errors, access issues and loss of control. In order to send text messages, students must have convenient access to their phones and have a cellular plan that allows sending messages. Students must enter two numbers when responding – the number to the specific poll must be entered as the phone number, then the student must enter a corresponding number for each answer. Poll Everywhere has recently updated its system to allow students to enter the actual alphabetic character that corresponds to the correct answer for a true/false or multiple choice question. In other word, the student need only type "T" in the message body to answer "True" for a true/false question. There is the chance that the students will not accurately type in these two sets of numbers. If a student does not have a phone in class, they may be unable to participate. Also, some cell phone plans do not allow the respondent to send messages to this program, but the reason some plans do not allow access is unknown. Also, some plans may limit the number of text messages, so students may be reluctant to use their limits on classroom activities. A resolution may be that if the student has a laptop, the site can be accessed from it; however, then an issue arises of having a laptop for every student. While not every student has a cell phone, it is more probable that a student will have a phone over a laptop in the classroom setting. As a precaution for educators, when asking for responses for a fill-in-the blank question, one must be prepared for whatever responses the student decides to send. Students may choose to send silly or obscene responses that are then displayed on the screen for all to see. This could be an issue because the instructor is unable to then delete the inappropriate response. Poll Everywhere has included a profanity filter that can be set to different settings in order to deal with obscene responses; however, there are tricks for getting around the filter that causes the filter to become pointless.

Plickers

Plickers is another approach to asking for student responses to multiple-choice or true-false questions. According to Plickers (2015), it "is a powerfully simple tool that lets teachers collect real-time formative assessment data without the need for student devices" (para. 1). The application is ideal for quick checks during learning to assess whether students are on track.

Instead of requiring students to respond through technology, the instructor prints cards that have barcodes from the website. The student holds up the card to respond to an A, B, C, or D response. The instructor uses a cell phone or tablet to scan the classroom and tally the responses, which can then be displayed on a

computer screen. As the instructor scans the room, each response is shown on the phone screen to verify that each student's response is recorded. Student names can be entered in the program to correspond to a particular card so that responses can be tied to a particular student. If a student decides to change their answer, the card can be re-scanned and the answer is correctly tallied. This method allows for a very efficient check of student understanding so the teacher knows whether to progress further into the lesson or to re-teach concepts that have not been accurately learned

Some of the main advantages of Plickers include free access, ease of use, and instantaneous feedback. Basic features are free to use, and signing up for an account takes only a few minutes, and one only needs to provide an email account for access. Questions can be generated in the system in minutes so that they can be used immediately or saved for later. The questions can then be displayed as students hold up their cards. There is no delay as cards are scanned because the instructor can see the student responses on the phone or tablet screen and know if the card was scanned and exactly which answer the student chose. Tallied responses can then be displayed on a computer screen for the class to see. Assigning a card number to each student allows the instructor to know how each student answered on a particular question, which can be recorded as a grade if needed. This provides more accountability for specific students.

Plickers also has its disadvantages, too, which include being time consuming, costs of printing, and limited grading ability. Plicker cards must be handed out and collected each class period, or each individual student must remember to bring it to class each day. Cards must be printed out, so the costs of paper and ink can be a deterrent to instructors. Card stock is recommended so that cards last longer, because if the paper becomes wrinkled, the response will not be registered. The cards also cannot be laminated because a glare from the lights on the lamination affects the ability of the digital device to scare the card. However, the advantage of being able to identify each answer with the respondent for grading purposes is limited. The instructor still must manually tally each answer because Plickers does not currently have the ability to combine answer responses per card (student). Students may also quickly become bored with using the cards because they are not the ones using the technology. As a result, teachers must constantly find new ways to challenge the student to stay engaged in the activity; such as, awarding points for right answers, allowing students to scan the other students' cards, and having students compete against each other with who can hold their card up first.

Geddit

Geddit requires every student to have access to a digital device in order to "check in" with the teacher on whether they understand the material (get it) or if they need assistance. Using cell phones, students check in with the teacher by indicating their level of understanding on a five-point scale. The application provides private and instant feedback to the instructor and allows the teacher

to check understanding during a lesson (Geddit Inc., n.d.). With a glance, teachers are able to view the results submitted by students and make the decision to reteach the concepts, continue developing the concepts, or progress to the next step in the lesson. By viewing that students are in need of assistance, teachers are able to differentiate instruction in the classroom based on student self-assessment needs.

An advantage of Geddit includes the ease of setting up the online classroom by giving students a code specific to their classroom and allowing them to input all necessary information. This saves time from the teacher having to place each student individually into a classroom. Students also do not need an email address in order to join Geddit and are only required to create a username and password to join. The teacher can add a lesson reflection on how to improve the lesson during its next use. In addition, students can "raise their hand" in the application to let the teacher know they need help while independently working. Students can also review their progress and review how they have advanced over time by their responses to their check-ins. An added feature is that Geddit times the lesson so that teachers can review the amount of time it takes to instruct particular lessons and can develop their time management more effectively. Geddit also keeps track of student data so teachers can review how a student performed on concepts over the course of a set time period. This is a major advantage for teachers required to track progress monitoring of students for response to intervention (RTI) or special education documentation. Using Geddit to assist with documenting a student's response to intervention meets the definition of RTI being "…a prevention oriented approach to linking assessment and instruction that can inform educators' decisions about how best to teach their students" (National Center on Response to Intervention, 2010, p. 4).

A disadvantage of Geddit is that the system is solely reliant on students being honest with their check-ins about their level of understanding of the lesson. A student has the option to select that he or she completely understands the material, does not need any help, and can, therefore, proceed in the lesson even if he or she does not understand the material. Another disadvantage is that students who use a mobile device to access the Geddit application sometimes have delays in their check-in registering with the teacher device. This student comprehension check method also requires every student to have access to a device in order to check-in with the teacher which can be costly for school districts in providing a 1:1 student to technology ratio classroom. If students are asked to bring their own devices, a public school district would have to resolve issues of students utilizing their data plans to access the Internet, which can become costly for parents.

CONCLUSIONS AND RECOMMENDATIONS

All three applications, Poll Everywhere, Plickers and Geddit, have promise for engaging students in the classroom. The students were responsive to new uses of their cell phones, and they generally appreciated the tactile activity. This observation is supported by Wynn's (2013) study of student perceptions of the use

of technology as being a valued addition to the classroom. However, instructors should remember that not all students will be prepared to use technology, and some students will not be as proficient in its use. This difference in proficiency was shown in the use of Poll Everywhere as some students had difficulty in knowing how to respond. Although instructions were displayed on the screen and the instructor verbally gave the instructions, students had to be diligent to type in two sets of numbers correctly. There was also a noticeable lack in availability of technology due to students that did not bring their own devices or did not have cell plans that allowed the application. These shortcomings support the idea that not all uses of technology are appropriate in all situations.

A level of maturity must also be considered when utilizing these programs in the classroom due to self-assessment and honesty required of students. Using these technology supports in the classroom is also difficult if the technology is not available for all students to use. One observation made through the action research was that not all students had access to a phone or computer in order to use it in class for the designed purposes of the lesson. This reason is why the authors chose to include Plickers because teachers only needed to print and distribute cards to use the technology; however, the students can quickly become bored because they are not the ones utilizing the technology. The cards do engage the students to some extent because it has the students doing some physical activity, but the instructor found that by allowing the students to help scan the cards, there were more students actively involved in the learning process. The students would compete with each other in order to be the "winner" of utilizing the technology to scan their fellow classmates' responses.

Also, technology is always progressing and adapting, as was shown in how Poll Everywhere updated its system during the course of the study. This change of allowing students to only enter an alphabetic response in the message body, instead of a corresponding number, was updated after the instructor first used the application during the study. The students also had to join instructor's account each class day the technology was used, which did take a small amount of time as students had to type in additional information at the start of the lesson. Just as technology progresses and adapts, it can also become obsolete. One online program the researchers considered utilizing for this article shut down the program without warning. The researchers developed a lesson the week before the program was going to be used and on the day of the lesson, they discovered that the technology was no longer available and the instructor had to quickly change plans for the day.

All aspects of technology are dependent on many outside variables, so teachers should always remain flexible when utilizing technology for student engagement and comprehension checks. Students should be instructed on understanding that technical issues arise, and teachers should be patient and flexible in dealing with the problem. Nothing can take the place of an effective teacher, and technology is only one of the means that teachers can use to

instruct and assess student learning.

Students were asked if they enjoyed using the new technology tools, and many responded that they did. However, they stated that they also like the "old" technology. Using these tools was good for engagement, but it did not provide study tools like a traditional lesson does. A traditional lesson is more likely to provide handouts and other documents that a student can use to study for assignments and future assessments, but the use of technology in these instances did not provide this reference. Students did state that they missed the printed quizzes that they had returned to them for study references.

One recommendation is that student engagement utilizing technology for student feedback can lead to higher-level critical thinking skills in students. Snyder and Snyder (2008) state that:

> The premise that critical thinking is to knowing as listening is to hearing implies that critical thinking is a learned skill that must be developed, practiced, and continually integrated into the curriculum to engage students in active learning. To support this premise, focused attention needs to be placed on the application of content, the process of learning, and methods of assessment (p. 98).

By utilizing technology to gain feedback from students and check their comprehension on the topic being taught, focused attention can then be placed on the application of the content to ensure a smoother and stronger delivery to students. Student feedback can give valuable information to the teacher in regards to the process the students utilized to learn the concept taught and give the teacher more reassurances that students can apply the concepts.

Future research could determine if extended research into the effectiveness of these technology programs improves student learning and retention. The research could ask additional questions of students to assess how relevant the programs are for learning and retention of concepts as compared to traditional learning methods. In addition, reviewing additional technology tools in the classroom to provide more variety would also provide insight into, perhaps, more effective tools. These applications were only used for a few days during class, and extended use of these tools may provide more insight into their effectiveness, especially if they are effective for prolonged engagement.

Future research could also assess how utilizing these technology tools for engagement compared with the age of students using them to determine if students at lower grade levels felt more engaged than students at higher-grade levels. The tool used could also be evaluated to determine if certain tools were determined to be more favorable at specific grade levels. This would be significant information for the companies creating the technology tools to better conform

the tools to fit the needs of teachers and students.

By utilizing the tips of using the technology tools featured in this paper, teachers can "…aid students in using feedback more productively…" (Johnson, 2012, p. 72) and allow teachers to utilize pedagogy that encompasses all activities used in learning and to "convey the ideal of enlightened teaching" (Kindsvatter, Wilen, and Ishler, 1996, p. 6). In addition, using variety in the classroom will help increase student interest (Kindsvatter, Wilen, and Ishler, 1996). Technology helps to provide the variety of teaching methods that will aid in student engagement. Utilizing technology tools for student feedback through these informal assessments assists in learning by providing variation in the lesson, engaging students in the material, and providing necessary feedback for better classroom learning.

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MODELS TO TEACH SECURITY-QUESTION IMPROVEMENTS

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ABSTRACT

Security questions are used for secondary authentication. Users are prompted with security questions that require private knowledge that only a valid user has. Security questions offer a low-cost alternative to password resets and provide an additional layer of security beyond the traditional means of usernames and passwords. In this paper, we propose two models that can be used to teach students how to improve the quality of security questions by improving the questions' repeatability, memorability, and strength. The first model interconnects the factors that affect response usability, and the second model analyzes user responses to security questions.

Keywords: Security pedagogy, user authentication, information security

1. INTRODUCTION

Security questions, such as "What is your favorite color?" are considered a viable alternative for secondary and supplementary authentication. Security questions, also referred to as security, secret, or challenge questions, are a common approach to authentication, providing a secondary form or an additional layer of authentication. Security questions are based upon information the user already knows and can readily recall while being sufficiently private to make it difficult (if not impossible) for others to know (Just and Aspinall, 2009). Security questions can offer a low-cost alternative to password resets and an additional layer of security beyond traditional username and passwords. Security questions are a human-authentication method leveraging authentic users' unique private knowledge. Information system security is meant to protect and limit access to select individuals. However, all access control techniques, including security questions, are susceptible to attackers. In particular, security questions are susceptible to three types of attacks: blind (brute force), focused (statistical) guess, and observation (research/personal). Any proposed solution must address existing and potential threats by balancing usability, privacy, trust and security.

This paper adds a data acquisition engine, and a security metric within it, to the traditional security-question research model. This paper presents models for students and instructors of security on how informing users of potential security threats may improve security with minimal effect on usability, privacy and trust. We define usability as a combination of repeatability, memorability, and strength of cognitive passwords. We use repeatability as a variable that can measure whether the user is able to supply the correct responses over a period of time and intervals. We use memorability to measure whether the user could recall their responses by comparing user responses with a later response to the same question over a defined period. The strength of the user response is measured mathematically to indicate how difficult the response would be for a hacker to break.

To achieve the goal of the paper, a data acquisition engine with a security metric are integrated into a traditional security question framework. The data acquisition engine gathers individual responses and reviews the information to determine the entropy of the response. Entropy, which is the measure of the security of a response, is determined by evaluating the responses based on the number and type of characters, similar answers, and responses available through various data sources. The security metric incorporates the entropy of the response and an assessment of the susceptibility of the response to a focused attack to provide an accurate assessment of the question and answer pairing. Data sources include public, semi-private and private data (including Facebook and search engine results). The available data sources are processed by the data acquisition engine to assess a response's entropy and strength and then inform users of the level of security of their response via a security metric. The security metric will assist participants in recognizing whether they are susceptible to guessing or focused

attacks and, in cases of low entropy, indicate a data source from which a similar response can be found.

Interactive designed security systems such as the one outlined in this paper can address identified entropy problems, improve individual security awareness and prevent low entropy responses. The paper proposes a solution to evaluate cognitive questions from both an individual and a system-wide perspective that increases security, awareness and usability.

To mitigate security threats, the proposed models hint at refinement to existing business processes through the assessment of an individual's supplied response to a cognitive question. An individual firm may have access to more users, diverse responses, and data to develop an improved process. Unique business processes such as in the case of the proposed real-time cognitive assessment system can be a source of sustained competitive advantage (Grant, 19991). The implementation must be flexible to support different type of answers based on changing responses from the whole population and the individual and provide continuous updates to responses gathered from users. In the final section, we propose in further detail how cognitive question authentication systems can be improved through guidance, awareness and pro-active security (GAPs).

The models attempt to improve security questions as a form of secondary human authentication and other forms of access control that rely on information known to the user. The web-based model offers a dynamic environment that can adapt to changes specific to an individual, the system's participants and the available data sources. The design has practical applications for improving the security of pre-existing and future security-question implementations. Overall, the paper builds on pre-existing literature to enhance the security research domain by mitigating current challenges with security questions as a secondary form of authentication.

Individuals are notoriously bad at and often incapable of retaining and recalling high-quality passwords (Ellison, 2000; Kaufman et al., 2002). When users forget passwords that they are forced to memorize, security questions can offer an alternative method for password recovery. Access to secure accounts can be acquired through a series of questions easily recalled by the user, but not by an imposter, that can be used to reset the original password. Additionally, security questions can provide an additional level of security to existing username and password or other single-factor authentication methods. Security questions attempt to strike a balance among usability, security and privacy.

As increasing amounts of personal information are captured through public records, shared through social media, and otherwise made accessible over the web, the development and use of security questions in the security domain becomes increasingly insecure. Concomitantly, there is value in a research focus that both investigates the emergent risk to security of security questions and that

transitions this newfound understanding to the development of more-viable methods for the use of security questions. Security questions, as with other secondary security systems, have increased in attention among authentication scholars who examine the intersection of authentication and usability (Reeder and Schechter, 2011). As researchers have noted, the evaluation of security questions as a form of secondary authentication requires a balance between usability and security. Although studies have explored methods to evaluate security questions (Just, 2004; Just and Aspinall, 2009), the focus has remained more on the use of security questions and less on their actual construction. Considering the development of security questions presents a valuable addition to the literature; as secondary security approaches garner increased attention, demand will increase for solutions that balance user-centric design and security and that consider potential and emerging threats.

This paper outlines a novel and alternative approach to the design and evaluation of security questions. The research benefits security teaching and research, individual firms considering or utilizing security questions, security personnel and individual users. Current secondary authentication systems have widespread weaknesses (Reeder and Schecter, 2011) that affect all stakeholders. Each identified stakeholder in an authentication mechanism – attacker, user, and host – has his or her own concerns. An attacker wants to guess the user's response with the least amount of effort (min-entropy). A user wants to be able to respond with the least amount of effort while understanding the risk that an attacker may guess the user's answer. A host wants an attacker to guess a response with the maximum amount of effort (max-entropy). To ensure that a user has the maximum amount of entropy, the host has two options: provide an answer that will incur max-entropy or warn the customer of the strength of their answer.

Given the ubiquity of security questions across various industries, research into improving secondary authentication is important. Likewise, it will assist in improving security awareness through highlighting weaknesses in current systems – specifically, through highlighting the disparity between question entropy and system security.

2. Literature Review

Zviran and Haga (1990) originally proposed the use of cognitive passwords as an alternative method to passwords that were difficult to remember or easily guessed. Their research indicated that cognitive passwords offer both security and usability. The passwords are difficult for others to guess who might have information of the knowledge domain of the question, such as family members or strong-tie relationships, but sufficiently easy for the owner to recall. The advantage of security questions over traditional passwords is memorability. The disadvantages of security questions include a longer setup time, ambiguity over correct answers (e.g., determining the response to "what is my first pet's name?" in a multi-pet household [*applicability*]), the potential for temporal decay of answers (e.g., my favorite song might change over time [*repeatability*]) and complexity of multiple responses

(e.g., larger question sets may undermine memorability). Despite these shortcomings, the authors viewed cognitive passwords as a viable authentication approach.

The primary drivers for implementing cognitive passwords as a secondary form of authentication stem from the common use of cognitive passwords in automated password recovery systems. In these systems, in which cognitive passwords enable self-service of password recovery, factors of convenience, time, and cost savings help rationalize their use. Firms can rely on existing infrastructure to implement security questions without significant cost or major changes in security policies. Security questions allow for faster incorporation into existing systems than do alternative measures such as hardware tokens or biometric scanners because minimal if no additional hardware/setup is required and training is minimized. Secondary authentication, including security questions, that requires nominal technology investment is desired (Irakleous et al, 2000). Security questions are meant to be easy for the user to recall, but hard for an imposter to guess (Just and Aspinall, 2009). Instead of traditional memorization and repetition, the user should already know the answer to security questions. However, researchers have identified weaknesses in this form of authentication because both the questions and answers are susceptible to attack (Bonneau, et al., 2010).

Reeder and Schecter (2011) identified reasons why security questions fail. First, the questions available to users were not configurable. Some available questions are not applicable to some users including "name of the first pet" for non-pet owners or "favorite sport team" for someone who does not enjoy sporting events. Alongside a lack of flexibility and options, some questions are difficult to remember, a condition that conflicts with the perceived benefit of using security questions for authentication. A second cause of failure was the answers being known or easily guessed by close contacts including friends, family and acquaintances (Haga and Zviran, 1991; Pond et al., 2000; Schecter et al., 2009). The final identified failure occurs when some of the user responses can be found through a) public records (Griffith and Jakobsson, 2005), b) databases (Lindamood et al., 2008;) and c) social media (Rabkin, 2008). Overall, the answers to the questions do not follow the same restrictive guidelines as primary authentication passwords (Mohammad and van Oorschot, 2007). Furthermore, security questions have lost the original luster outlined by Zviran and Haga (1990) due to the use of search engines, data stores and the wide accessibility of personal information available via social media. Just (2004) recommended further research in the area of challenge questions, with a focus on new approaches, improved validation and usability.

An overall interest exists in developing systems that protect user security better. Security questions as a form of authentication have drawn scrutiny because information systems are being broadly used by the public. Despite the prevalence of security questions in banking, (Mannan and van Oorschot, 2007, Rabkin, 2008) and web-based mail providers (Schechter et al, 2009; Keizer, 2008), studies are

starting to raise (Reeder and Schecter, 2011) and address concerns from the security community (Bonneau et al, 2010). Security risks exist in not only the questions being used but also the answers that are known, possible, and searchable. Security questions are evaluated based upon entropy (Jakobsson et al., 2008). An ideal authentication would balance reliability, security, authentication and setup efficiency (Reeder and Schecter, 2011) to obtain high entropy.

Two of the original champions of security questions, Zviran and Haga (1990), were impeded by their inability to "conceive of people in social roles who would have superior personal knowledge of the user-respondents than their spouses, parents, siblings or girlfriends/boyfriends" (pg. 141). More than two decades later, the emergence and accessibility of personal data resources (public/private), social media and other information-sharing instances and sources of common answers to security questions have placed further strain on the ability for security questions to serve as an appropriate authentication mechanism.

As an alternative to a single password approach, Zviran and Haga (1990) found security questions were a viable alternative, citing better memorability and usability than traditional passwords in addition to meeting security requirements. Further empirical testing by the authors found security questions to outperform alternative approaches (Zviran and Haga, 1992). Just and Aspinall (2009a, 2009b) found conflicting results to those of Zviran and Haga (1992). When users were offered the chance to create their own passwords, the generated questions were insecure. Even when responding to their own generated questions, users had trouble recalling the answers. The overall trend was that low-entropy responses placed participants at risk of compromised security. Rabkin (2008) also noted the use of mined social media information would aid attackers, making security questions a weak secondary authentication choice.

The proposed research extends previous literature investigating security questions. Building on the benefits initially suggested by Zviran and Haga (1990), the paper attempts to compensate for potential security weakness while balancing the negative effect on usability. Because security questions have become more pervasive as a tool for secondary authentication, opportunities exist for examining and proposing solutions to new security risks.

3. Methodology

In this paper, we propose a novel cognitive password authentication model that can be used to discuss security questions in classrooms. The models build on the strengths of cognitive passwords (chiefly their ease of recall and greater entropy). They also address the core weaknesses of the model (the lack of uniform answers and public accessibility to question answers) through the use of a web-based data acquisition engine that harnesses public, semi-private, and private data sources to assist in the development of security questions and support users in creating secure, well-distributed answers. Such a system would build on

emerging means for identification of patterns across a user's personal data and those of the user population.

The paper proposes a dynamic system that adapts to changing patterns, adapts to known human cognitive limitations (Miller, 1956), and allows for the assessment of security question and answer pairings while balancing applicability, memorability and repeatability. Because security question responses are subject to change and can be exploited for security weaknesses, the paper proposes a novel solution. The proposed approach has real-world application to business information systems. Through public, semi-private and private data sources, most users make varying degrees of information available that may affect the security of their account either knowingly or unknowingly. A balance must be maintained between each user's security and his or her effect on the whole through shared responsibility.

This paper utilizes an environment that imitates current security question systems. The proposed web-enabled system for testing security questions builds on earlier work although changing the testing methodology from paper-based to a purely electronic system. Additionally, the use of a dynamic security metric is incorporated into the paper. The metric evolves over time as more information is gathered from users, outside data sources and entropy thresholds.

A benefit of a data acquisition approach to security questions is to further the development of a security mindset that encourages users to improve their individual security. Users will be aware of the availability and security of their responses to security questions. In identifying the source of potential data weaknesses, users should be able to acknowledge and correct low-entropy responses and behaviors that could put their security at risk. Singh (2006) stated that the most effective means to increase Internet banking security was through ease of use, convenience, personalization and trust. Singh's suggestions support security questions being vetted through a dynamic system to improve the security of secondary authentication.

The security metric is the output of assessing the user's response using entropy (Shannon, Guessing and Marginal Guesswork calculations) in addition to the susceptibility of the response to a focused attack based on data gathered about the user. The proposed security metric can serve as a module to plug into existing and future security question implementations. The enhanced security provided by the data acquisition engine incorporates user and group data to evaluate individual and population security risks. Because each security-question authentication system has its own unique distribution of answers and responses, the security metric provides instance-specific pattern and data analysis. Based on the proposed research, the security metric should increase user awareness of potential security risks to security question authentication not implementing the proposed model. Figure 1 illustrates the traditional model of security questions. The figure shows various types of security.

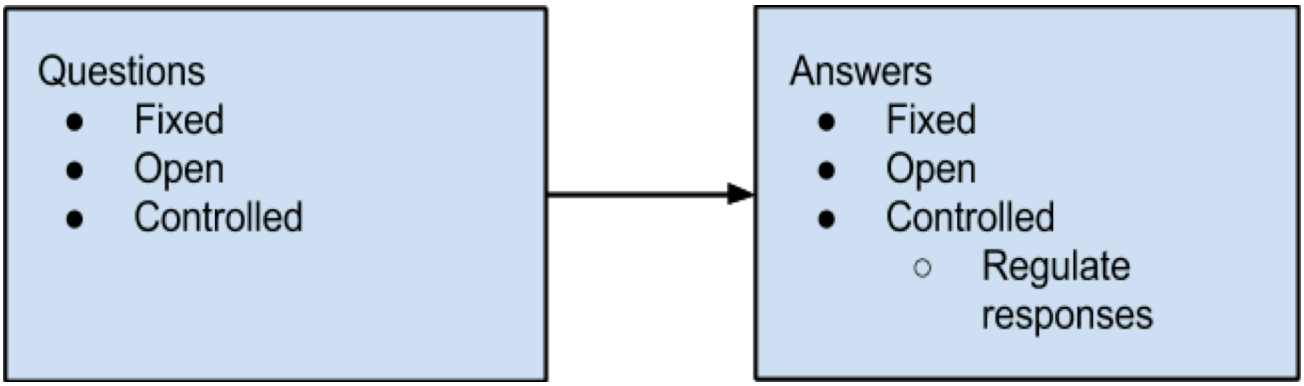


Figure 1 – Traditional Security question Model

Questions can be classified into both the type of potential answers and the type of information requested. Just and Aspinall (2009b) outlined six different types of question classification – proper name, place, name, number, time/date and ambiguous. Proper name includes last name, first name, first and last name, pet name and other name. Additionally, most questions are posted as *something you know*, but Schecter et al. (2009) security questions illustrate *something you have*. Google included frequent flier number and library card number, which few individuals would know from memory. This paper attempts to identify whether question classification influences response strength and whether the security metric influences question classification selection.

In terms of security and usability, a fixed answer set may reduce the likelihood of selecting an insecure answer but also may impede applicability, memorability and repeatability of the response. Open questions may allow users to enter their own response, but the answers may remain highly insecure and suffer usability issues. Controlled answers are regulated to enhance the positive aspects of both fixed and open answers. Security question systems could add fake questions and control user answers to assist users to produce more secure responses (Just, 2004). This paper adopts the perspective that both controlled questions and controlled answers can be used to protect privacy and improve security while maintaining usability.

The proposed solution may also apply to other forms of authentication through the addition of a data acquisition engine when examining population and individual responses. Traditional text and graphic passwords used for authentication could adopt similar pattern analysis to create uniform secure distributions. Captured information could be shared securely among a pool of systems to improve protection of individuals and groups.

3.1 Model Goals

As discussed in previous sections, improving security while avoiding negatively affecting usability and privacy were identified as the most appropriate areas for

research in security questions. Entropy, which is used to determine the level of security associated with security questions, is the measurement used to evaluate security questions against various attacks. The specific types of security questions and answers were explained to identify potential security flaws. Subsequently, three types of security attacks were explored to outline the approaches and data sources available to a would-be assailant. A balance must be struck between usability and security. Systems should strive to develop a user's "security mindset," which helps to identify weaknesses and opportunities for attackers. Security question implementations should assist individual users while protecting the larger participant body. The proposed model is meant to improve the security awareness of individual users while leveraging available data to identify risks without compromising privacy and usability.

3.2 Model Development

Just and Aspinall (2009a; 2009b) outlined the challenges associated with developing experiments to evaluate authentication mechanisms. Participants must be willing to share private information with a stranger that might be used to identify the participant. An experiment must have the ability to emulate an actual authentication system and balance individual privacy. Previous studies have leveraged pen and pencil surveys to evaluate security questions. Any proposed experiment must be able to capture information about the user's responses and provide examples of the information that would be available to friends, family and attackers to determine the security, usability and privacy of the answers and questions.

Surveys attempting to examine information known to observers are constrained by the memories of friends, acquaintances and relatives. However, we propose that these observers have at their disposal direct access to a vast array of digital resources. The data could be used by an imposter to answer an individual's security questions. A system that has access to electronic information (public, semi-private and private) as we propose would be more effective at analyzing potential threats. An information system could perform analysis on response trends, review answers across data sources, and analyze user response strength for security questions and answer selection. Few, if any, studies have attempted or been able to replicate a test environment to evaluate security questions to the extent explored in this paper. Furthermore, no attempts have been made using an acquisition engine to gather data sources, identify response trends and distribution, support user-developed questions and propose new question designs to improve security question security and usability.

The literature supports a dynamic security question system that monitors supplied answers to determine the associated risk (Schecter, Brush and Egelman, 2009). Bonneau et al. (2010) suggested that questions should be controlled to improve security. An example of reviewing security questions was managing

the answer distribution of surnames to prevent common English names being over utilized. Rabkin (2008) suggested information shared on Facebook could be used to leverage an attack, and Irani et al. (2011) emphasized information is leaked through social networks and could be aggregated to affect security. Some information is publically available through government records (Virgial and Jakobsson, 2005) and through web-based channels that provide common passwords and responses (Burnett, 2011)(http://xato.net/tag/top-10000/). We propose a novel process that attempts to assess the security risk of an individual user's security question and answer selection that does not significantly affect usability.

The proposed model could be evaluated using the four methods outlined by Bonneau et al. (2010). The authors documented a study on statistical attacks for names as a response to personal knowledge questions. The first method utilized Shannon (1948) entropy to determine the strength of a user's answer. The second method utilized for guessing entropy was introduced by Massey (1994) and later named and further evaluated by Cachin (1997). Next, I calculated the marginal guesswork algorithm introduced by Pilam (2000). Finally, the marginal success rate, adapted from Boztas (1999) and outlined by Bonneau et al. (2010), was used to determine the success rate after a number of guesses.

4. Proposed Model 1: Interactions between Factors Affecting Response Usability

In this section, we propose and explain a model that identifies and interconnects the factors that affect the usability (repeatability, memorability, and strength) of cognitive responses. We present a model to explore the following research question: Can the visibility of a security metric improve security-question response strength and awareness of security question attacks while minimally affecting usability?

4.1 Model Details

The research includes the implementation of a software-based security metric that incorporates a user-centric analysis of security-question security threats including blind guess, focused guess and observation attacks. The web-based testing environment closely reflects existing secondary authentication systems. The study's experiment gathers information on the individual and the distributions of likely answers and common answer sets. The participant's response is evaluated based on the security-question security threats. The security metric is also intended to raise the participant's awareness of security threats. Additionally, the security metric should aid the creation of high entropy and security responses while minimally affecting usability. The designed experiment strives to aid the user's development of secure responses and improve the overall design of cognitive authentication systems.

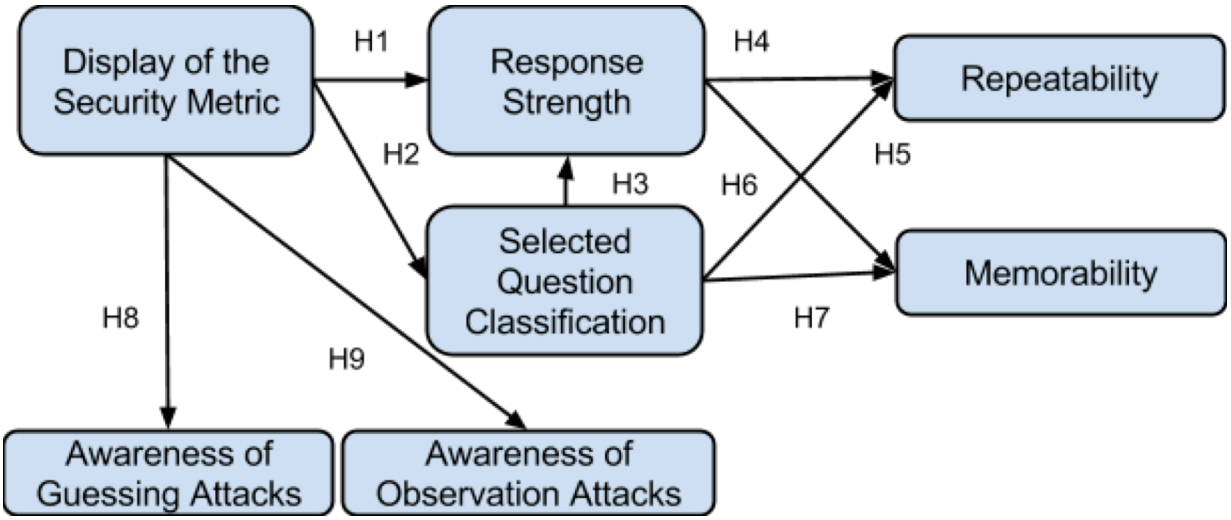


Figure 2 – Proposed Model 1: Interrelation between Factors Affecting Response Usability

As shown in Figure 2, the first proposed model suggests relationships between the following factors:

H1 - The display of the security metric is associated with response strength.
H2 - The display of the security metric is associated with the selected question classification.
H3 - The question classification is associated with response strength.
H4 - The response strength is associated with repeatability.
H5 - The response strength is associated with memorability.
H6 - The question classification is associated with repeatability.
H7 - The question classification is associated with memorability.
H8 - The display of the security metric is associated with awareness of guessing attacks.
H9 - The display of the security metric is associated with awareness of observation attacks.

Display of the Security Metric: The first hypothesis refers to the relationship between the displayed security metric and a user's response based on the visible security metric. The security metric refers to the data acquisition engine's output, which identifies the level of entropy and the levels of security of the participant's response as outlined by Just and Aspinall (2009b). The entropy of the response is determined based on potential blind and focused guessing attacks and the availability of information to the public, family and friends. Only the lowest security score is reported via the security metric, based on the user's answer. All participants will be required to select ten question-answer pairs. Only the experimental group will have the security metric displayed. The goal of H1 is to determine the effect of the security metric by assessing user response strength. Previous studies have not attempted to evaluate the strength of user responses or to use a security metric

in a near real-time setting to make participants aware of the response strength. H2 attempts to assess the effect of the visible security metric on question classification selection. We propose that the display of the security metric will encourage the selection of questions with higher answer spaces (the number of possible responses). H8 and H9 propose that the display of the security metric will improve security-question security awareness of guessing and observation attacks.

Response Strength and Usability: The next set of hypotheses investigates the relationship between the security question responses provided by the users and the ability of the users to repeat and remember their responses.

Selected Question Classification: The third area of analysis is the type of question associated with response strength and usability. The question classification is proposed to affect the response strength. However, the same question classification is proposed to affect both repeatability and memorability.

4.2 Model Benefits

The proposed model extends the literature by providing help in several areas. First, the model provides guidance to users in selecting stronger security questions/answers. The literature suggests that users do not create questions with high-entropy answers (Schechter et al, 2009). Schecter et al. (2009) explained that users must understand and learn about specific security threats and generate cognitive questions that meet both usability and security concerns.

The proposed model also increases security awareness, helps in taking pro-active security measures rather than post-active actions, and helps enhance security. The enhancement attempts to utilize the same tools an attacker would use to target both unknown and known individuals. The enhancement attempts to assist both the individual user and all the users of the model. The data acquisition engine gathers known distributions of answers for guessing attacks while seeking out user-specific responses that affect security and do not follow the same distributions. A primary potential source of user-specific answers for the data acquisition engine is information available through Facebook. Additional social media and data sources, beyond the proof-of-concept model use of Facebook, may be used to compile a list of options from the user population. Beyond social media, additional public and semi-private data sources could be and may be incorporated into the data acquisition engine. The goal of the supplementary resources is to strengthen the data acquisition engine to improve the accuracy of the security metric.

On the question side of the input, users will be encouraged to suggest questions in the survey part of the experiment. We require users to create their own security questions and then test the strength of the proposed questions. The paper suggests that the security metric should help participants learn about potential

security threats, which could increase the likelihood of users generating secure security question and answer pairings.

5. Proposed Model 2: Analysis of Responses

In this section, we propose the second model, which shows how the user-response analysis can be performed.

Model Development

Just and Aspinall (2009b) and Bonneau et al. (2010) laid the foundation for our proposed model, which includes the use of the data acquisition engine. Both articles supported earlier studies' criteria for privacy, security and usability. Just and Aspinall (2009b) developed a model to define security attacks based on the information available to an attacker. The proof-of-concept model was used to propose that an attacker would choose the method with the highest and quickest chance for a successful security breach.

Just (2004) proposed developing a framework specifically to evaluate security questions. The framework includes privacy, usability, and security measures for evaluating any challenge-question system. Usability is explained using three criteria: applicability, memorability and repeatability. Security criteria include guessing and observation difficulty. The security construct was expanded by Rabkin (2008), who raised concerns over the availability of personal knowledge through social media (Facebook) that could be used to attack security questions manually or automatically. Schechter et al. (2009) expanded both Just's (2004) and Rabkin's (2008) works by examining individual questions and users' answers to determine the security against various attacks while evaluating the effect of question security on reliability of questions and the user's willingness to answer a question. Rabkin's (2008) research on social media websites, specifically Facebook, outlines a non-traditional data resource that can reduce the security of cognitive questions. Complicating the collection of the information is the requirement to obtain an individual's permission. Only after approval can a user's pertinent data be used to analyze the supplied response. In this type of situation, the data could be analyzed on demand and never stored. Finally, Feeder and Schecter (2011) combined both usability and security to review a secondary authentication mechanism.

This paper adds the data acquisition engine, and the security metric within it, to the traditional security-question research model. The solid lines indicate a previous contribution to the literature, whereas the dotted lines indicate the paper's contribution to the domain. The arrows are directions to indicate the primary influence. Just and Aspinall (2009b) performed a security analysis via a hybrid online-offline experimental method. Although this approach may have afforded participants additional privacy, the proposed model offers real-time feedback that enables users to view the strength of their responses. The proposed security

attempts to provide a fully online experimental method that encourages participants to strengthen their answers based on gathered information. The security analysis also assists in the creation of questions that support high-entropy participant responses:

- The data acquisition engine will **push** the selection and analysis of security questions.
- The data acquisition engine will **pull** users' answers and **push** back the entropy of the answers.
- The data acquisition engine will **push** higher security.
- The data acquisition engine will **push** higher usability.

The proposed model 2 shown in Figure 3 incorporates a data acquisition engine to develop a security metric based on available information, common answers, and emerging answer patterns. This model is used for analyzing user responses to the security questions.

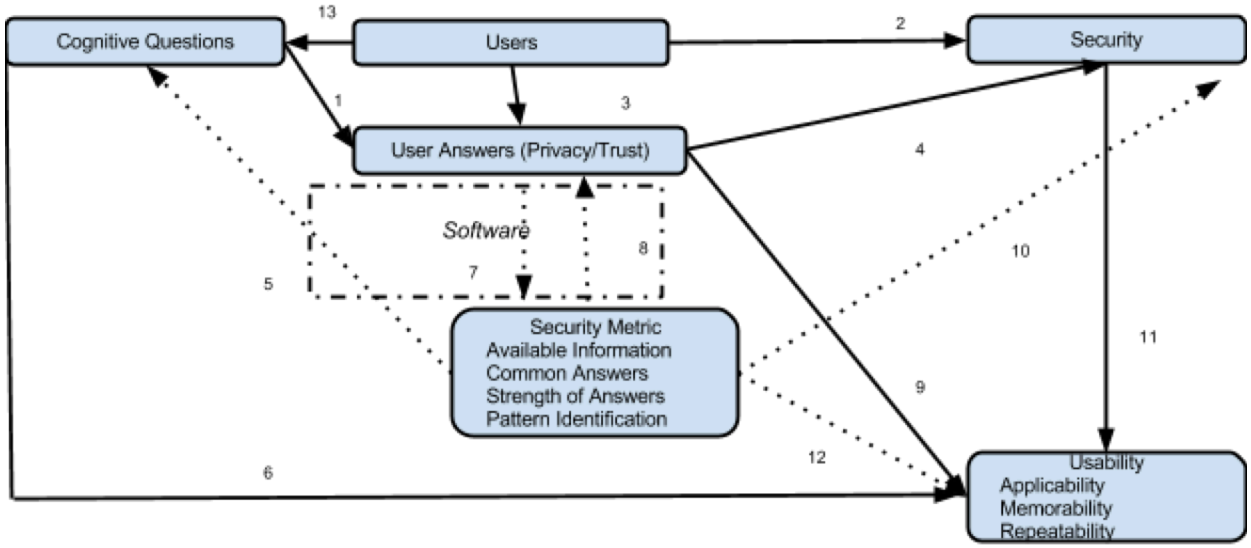


Figure 3 – Proposed Model 2: A Model to Analyze Responses

1. Security questions affect user answers.
2. Users are unaware of security question security risks.
3. Users limit cognitive answers based on privacy / trust concerns.
4. User-supplied cognitive answers are not secure (low entropy).
5. Proposed security metric can identify the strength (entropy) of cognitive questions.
    a. Proposed security metric can identify specific cognitive questions that users supply with low-entropy responses.
6. Cognitive question options affect usability.
7. User answers can be evaluated for entropy.
    a. User answers can be evaluated based on strength of responses.
    b. User answers can be evaluated based on all user responses.

c. User answers can be evaluated based on a pool of available or "most-likely" responses.
d. User answers can be evaluated based upon their available public information (Internet Search).
e. User answers can be evaluated based upon their available semi-private information (Facebook).

8. Users will strengthen their question/answer choice based on a security metric (indicator).
9. Users will supply highly usable answers (Applicable, Memorable, Repeatable).
10. Proposed security metric influences cognitive question security.
    a. Proposed security metric influences security awareness.
11. Security of security questions will affect usability.
12. Proposed security metric influences security question usability.
13. Users select questions that prompt for low-entropy answers.

Just and Aspinall (2009a;2009b) combined earlier security concerns presented in the literature to develop the Challenge Question Security Model.Bonneau et al. (2010, 2012) explored the security threats identified by Just and Aspinall (2009a;2009b) from a mathematical evaluation of entropy for security questions (2010) and later for multiple web authentication schemes (2012) that has been adopted for this paper.

The mathematical evaluation of Bonneau et al. (2010) of the entropy of different attacks based upon available information is the cornerstone of the paper. Each attack is assessed based on the entropy of the response, similarity to other responses and the information available to an attacker on a specific individual. The use of software can gather information specific to the question and the participants. The information can then be used to make participants aware of low-entropy responses via the security metric, which is suggested to affect question and answer selection, security and usability. Furthermore, the use of pattern identification serves as a countermeasure as identified by Bonneau et al. (2010). The authors proposed that an active server manipulating answer distribution could directly affect the success of a guessing or focused attack. One goal is to assist users in the selection of secure security questions that will encourage a more uniformly distributed response. Table 1 outlines the variables, hypotheses and location for analysis used to assess the effect of the paper

Table 1 – Variables, Hypotheses and Testing Locations

Variable Name	Research Question / Hypothesis	Assessment Location (Experiment/Survey/Test)
Independent Variable (Treatment Variable): Security Metric	Can the display of the security metric increase the strength of security question responses? [H1]	Experiment
Independent Variable: Question Classification	Can the display of the security metric affect selection question classification [h2]	Experiment
Independent Variable: Security question Awareness	Does security question Awareness influence the entropy of responses?	Demographic Survey
Independent Variable: Security Awareness	Does security awareness influence the entropy of responses?	Demographic Survey
Independent Variable: Age	Does age influence the entropy of responses?	Demographic Survey
Independent Variable: Gender	Does gender influence the entropy of responses?	Demographic Survey
Independent Variable: Level of Education	Does level of education influence the entropy of responses and security awareness?	Demographic Survey
Independent Variable: Major	Does major influence security awareness and response strength?	Demographic Survey
Independent Variable: College	Does college influence security awareness and response strength?	Demographic Survey
Independent Variable: Password Creation Format	Does password creation format influence the entropy of responses?	Demographic Survey

Independent Variable: Social media use	Does social media use influence the entropy of responses?	Demographic Survey
Dependent Variable: Response Strength	Does the selected question classification affect response strength? [H3]	Experiment and Post-Experiment
Dependent Variable: Repeatability	Will response strength affect repeatability? [H4] Will selected question classification affect repeatability? [H6]	Post-Experiment
Dependent Variable: Memorability	Will response strength affect memorability? [H5] Will selected question classification affect memorability? [H7]	Memorability Test
Dependent Variable: Awareness of Guessing Attacks	Does the display of the security metric affect awareness of guessing attacks? [H8]	Experiment
Dependent Variable: Awareness of Observation Attacks	Does the display of the security metric affect awareness of observation attacks? [H9]	Experiment
Dependent Variable: Completion Time	Is there a significant difference in completion time between the control and experimental groups?	Experiment

The hypotheses listed in the paper have been added to the proposed security question model. Each of the six hypotheses is used to examine the addition of the data acquisition engine to the existing security question model.

6. Proofs-of-concept for the Proposed Models

We verified the proposed model using the methodology depicted in figure 4. A proof-of-concept methodology and software were built to demonstrate the capability of using a preliminary data acquisition engine to assist the security and usability of security questions. The proof-of-concept model applied some initial security approaches to address all three of the potential attacks outlined earlier. The resulting model shown in Figure 4 shows the data acquisition engine interpreting the inputs (questions/answers) to produce a metric of security based on the user's selection.

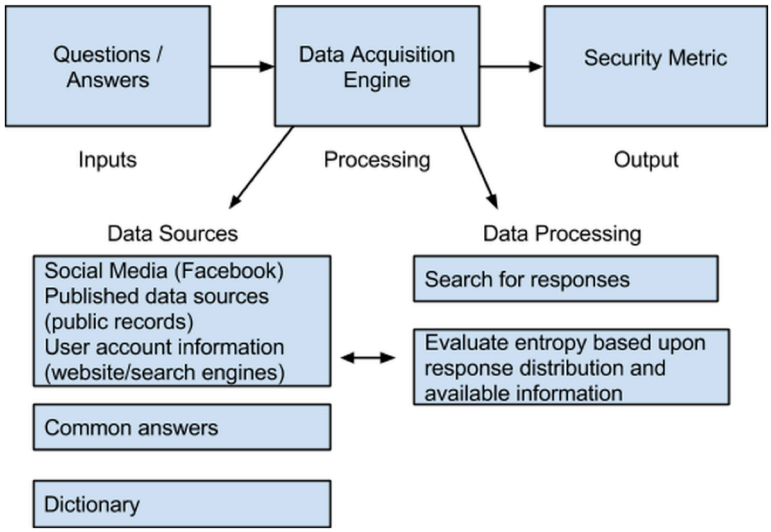


Figure 4 – Proof-of-Concept Methodology

The model presented in Figure 4 is the proposed security question process with data acquisition and security metric output developed to improve security while minimally affecting usability. The model has been developed to identify and exploit potential improvements in security question implementations. The model uses dynamic data sources to assess security risk for individuals and participants.

The modifications to models proposed in the existing literature can be classified into security and usability:

- Security: The addition of a CAPTCHA after a user has selected their questions and entered their answer protects against blind-guess attacks. The CAPTCHA limits the speed at which a human can enter multiple responses and thwarts automated brute force attacks. Reviewing user responses against the top 10,000 passwords protects against focused guesses. The proof-of-concept model integrates Facebook [Friends List/Likes] to cross check answers that may be observable. Finally, a Levenshtein test is performed on answers to prevent one-character modifications that may be attempted by either an

observable or a focused attacker.

- Usability: The proof-of-concept model leverages existing Schecter et al. (2009) work indicating that users are familiar with answers, which we propose will improve usability. The model also utilizes a rough graphic for notifying users of the security level of their answers.

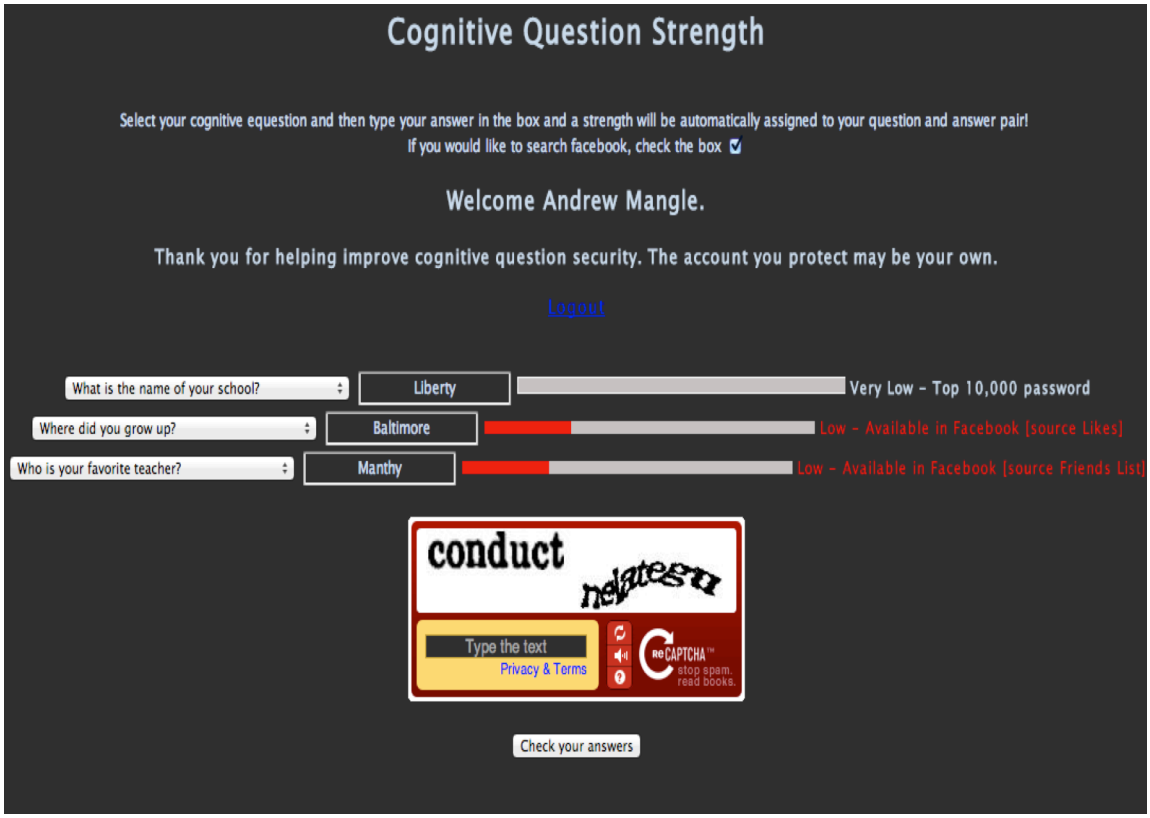


Figure 5 – Proof-of-Concept Software

Figure 5 shows the prototype software we created and made available at http://andrewmangle.com/morgan/. The software shows the feasibility of the model and its potential implementation. Once a user authenticates via Facebook, the system allows him or her to select and answer security questions. The responses are vetted through private and public data sources. If a match is found between the user response and available data, the user's security level is evaluated using the data acquisition engine, and the security metric is displayed with an explanation of the results. The results, not shown in the control group, identify the sources of reduced entropy. A low security metric may be linked to short answers, common response or availability via social media. The preliminary example is 100% functional and is subject to additional testing and modification.

The research suggestions, GAPs [Guidance, Awareness, Pro-active Security], are individually explained in further detail in each subsection. Guidance includes the feedback to the users of the system to help provide real-time information

concerning the security of their responses based on the information available to the host. Awareness includes the development of the security mindset to aid the user's understanding of the strength of their response and the availability/location of similar responses. Pro-active security includes monitoring security weaknesses including the availability of rainbow tables, answer sets and trends while dynamically analyzing collected data to assist users in the development of secure cognitive questions. Furthermore, cognitive question authentication should continue to stay abreast of emerging threats specific to the authentication approach, host, all of the users of the system and individual users.

6.1 Data Acquisition Engine

The data acquisition engine is the core driver used for assessing the entropy of a user's individual response against the known methods to compromise security question authentication. The data acquisition engine examines all components of the authentication method while supporting all key stakeholders. Questions and answers are evaluated for their applicability, memorability, and repeatability for the user and for security for users, attackers and the host. The data acquisition engine attempts to balance privacy and trust by requesting access to an individual's social media accounts while collecting other semi-private information. The responses are compared against available information to evaluate a user's susceptibility to a focused attack. The information is gathered and anonymously pulled together to protect all users against guessing attacks. Figure 6 shows the processes involved in the data acquisition engine and the cyclic flow of these processes.

Developers of security questions are always facing an unfair and advantaged opponent. Howard and LeBlanc (2009) call this concept attacker's advantage and defender's dilemma. The authors outlined four principle concepts of why attackers are at a clear advantage when cracking authentication systems. The first principle is that the defender must protect against all possible threats, whereas the attacker can choose the weakest point to attack. The second principle is the concept that the defender can only protect against known threats whereas an attacker can seek and exploit unknown weaknesses. Next, the defender must always be secure and constantly monitoring whereas the attack can strike at any time. The final principle is that the defender is forced to follow laws, ethics and regulations whereas the attacker has carte blanche to take any sort of action. The attackers have the strategic advantage; the data acquisition engine is meant to develop a tool that leverages all available resources to protect against known threats.

To be effective at improving the security of the system for all stakeholders, the data acquisition engine must review individual users, all users and non-participant information to assess/determine the level of entropy for brute force, guessing and focused attacks. To protect against blind guesses/brute force attacks, the data acquisition engine examines the overall entropy of the responses using

Shannon entropy and limits all responses to a minimum of six characters. To protect against guessing attacks, the engine analyzes patterns from collected data sources and then assesses the level of entropy using guessing entropy. Concerning focused attacks, the data acquisition engine requests that users supply access to semi-private and private information. To participate in the experiment, a user must grant access to their Facebook account. Overall, the data acquisition engine gathers data, identifies patterns that affect entropy, gathers individual and group responses and cross checks against responses in the order of brute force, guessing and focused attacks. In the following paragraphs, we explore the process used by the data acquisition engine to identify the entropy of responses based on each type of attack.

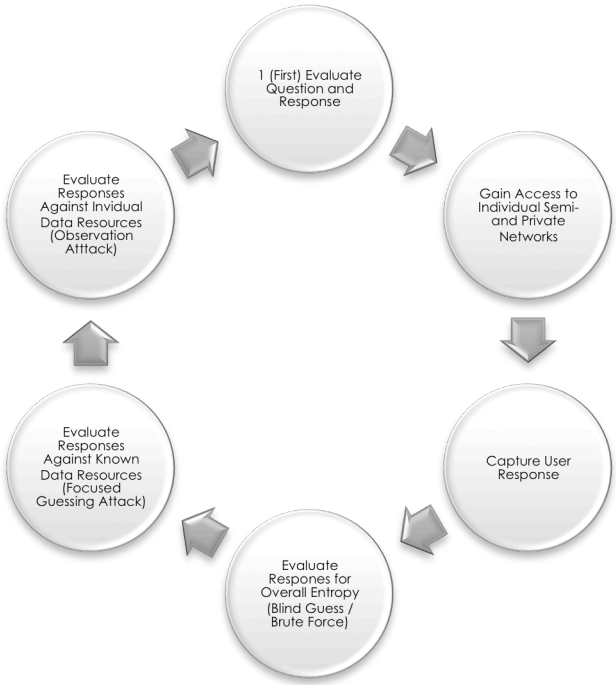


Figure 6 – Data Acquisition Engine Process Flow

The data acquisition engine works in a cycle that examines individual question strength and answer responses to security questions, gathers information from available and supplied resources and analyzes entropy for all known types of security question attacks. The process begins when the user selects a question and completes the response. Entropy is a measure of answer strength measured in bits, with the larger number of bits representing a more secure response. Entropy, a measure of answer strength, is used to evaluate the strength of the cycle, which starts with high entropy questions identified in the literature, then begins to examine the strength of the pool of questions to determine the strength of the entropy of user responses. Consistently weak entropy questions are removed from the pool available to users over time.

The next step requests users to provide access to semi-private and private data sources. The paper outlines the request for Facebook authentication

based on the work of Rabkin (2008). Based on the data acquisition engine model, more social media and data outlets could be added. Once granted access to the data resources, relevant information is gathered and stored. The information is stored temporarily for the user and anonymized after completion of the cycle. In the future, user-selected questions can be directly linked to the sources of information that cause weak entropy.

After granting access to Facebook, the user must enter AGREE to consent to the study. Once AGREE is entered and the begin button pressed, the user proceeds to a demographic survey about the participant including their experience with security questions. After the completion of the survey, the user has a 50% chance of being selected to participate in the experiment in which the security metric will be shown. The participant, regardless of membership in the control group, will select questions and enter responses one at a time. The system will gather responses regardless of whether the user is in the control group. The responses are evaluated for their strength. Only those individuals who have been selected to participate in the experiment will see the security metric. For those in the control group, the security metric will be calculated and stored but the results will not be visible. For the experimental group, if the security metric is very low or low, the participant must select another question and try again. The number of question attempts will be limited to ten or ended after successfully entering five question and response pairings with a security metric of medium or higher. The control group will be able to proceed after five question and response pairings. The final step for both groups is the completion of a post-experiment study. All participants will complete the same survey after the experiment. At the end of the survey, a thank-you message will be displayed to the participants.

6.2 Response Evaluation of Blind Guess Entropy

Once the user has entered the response to the security question, the response is checked for overall entropy. Overall entropy is calculated based on the number and type of characters used to construct the response. Response entropy increases with the addition of upper and lower case letter, numbers, and special characters. The entropy calculation changes for each set of characters. Table 2 presents the amount of entropy in bits depending on the possibility of the type of a single character. This table can be used to calculate blind guess (brute force) attack entropy of the user response.

Table 2 – Entropy in bits of various strings

Response	Entropy of One Character (x)	Entropy in Bits (z)
Lowercase Letter	1 in 26	$2^{4.7}$ (log 26/log 2)
Uppercase Letter	1 in 26	$2^{4.7}$ (log 26/log 2)
Lowercase or Uppercase Letters	1 in 52	$2^{5.7}$ (log 52/log 2)
Numbers Only	1 in 10	$2^{3.32}$ (log 10/log 2)
Numbers and Lowercase or Uppercase Letters	1 in 36	$2^{5.17}$ (log 36/log 2)
Numbers and Lowercase or Uppercase Letters	1 in 62	$2^{5.95}$ (log 62/log 2)

Overall entropy can be calculated by examining the character makeup of the responses, then raising the entropy of the makeup of the response (x) by the power of the number of characters in the response (y) to determine the entropy in bits of the response (z).

$$2^z = \log x^y / \log 2$$

The calculation above can be skewed based on the addition of a single or a second character. Table 3 indicates the changes in entropy with single and double character modifications.

Table 3 – The effect of various characters on overall entropy

Word	Bits in Entropy
train	$2^{23.5}$ (log (26^5) / log 2)
Train	$2^{28.5}$ (log (52^5) / log 2)
Tra1n	$2^{29.77}$ (log (62^5) / log 2)

In the case of security questions, overall entropy is calculated based on the number of bits required to crack the response. Based upon NIST's criteria for medium and high entropy (medium – between 2^{34} and 2^{48} possible answers and high – greater than 2^{48} answers), the data-acquisition engine throws a security alert if the response has low entropy. In Test 1, we require each user to answer five

questions. For the experimental group, all questions and responses must achieve a medium entropy or higher. If the user does not meet the required entropy, the user will be forced to select a different question and try again. The user has ten attempts at answering security questions. Overall entropy is calculated based upon the responses for all answers.

6.3 Response Evaluation of Focused-Guessing Attack

After the user response has been evaluated and shown to have overall entropy greater than the medium threshold, the response is evaluated to determine Guessing Attack Entropy. Focused guessing attack (also known as statistical attack) entropy has been reviewed in the case of user generated PINs (Bentley and Mallows, 2005), indicating that a four-digit pin, due to user selection, does not offer the expected entropy of 1 in 10,000 (2^{13} bits of entropy). The distribution of PINs follows a power law distribution. An attacker trawling for PINS would be more efficient in guessing the most popular pins instead of a sequential approach to PIN identification. The guessing entropy is based upon the distribution known to an attacker, with the attacker attempting the questions and answers with the highest distribution and working to the least distribution.

The original concept of guessing entropy was introduced by Massey (1994) and later named by Cachin (1997). Guessing entropy reflects that an attacker will generally not approach security questions with sequential guesses. In a guessing attack, a user will attempt to respond to questions with the most likely answer and continue to answer until all answers are attempted. Although a response may have Shannon entropy, the response may be extremely popular. Guessing entropy can be evaluated by determining the overall distribution of all responses and attempting to assess the likelihood of the user's response. Table 4 shows a hypothetical response distribution to the example question.

Table 4 – Hypothetical response distribution to the example question

Response	Frequency	Entropy
Las Vegas	25% (1 in 4)	2^{2} log (4) / log 2
Paris	20% (1 in 5)	$2^{2.32}$ log (5) / log 2
Orlando	10% (1 in 10)	$2^{3.32}$ log (10) / log 2

Focused guessing entropy is calculated based on an attack using a known distribution, which continues indefinitely until an answer is found. An attacker is specifically focused on a single user. This type of attack can be prolonged by encouraging users to avoid common responses and to modify the overall answer distribution. In the proposed data-acquisition engine model, data sources

including those captured in the cognitive authentication model are crosschecked against an individual's response. If the user response matches a response in our database, the system notifies the user of the low entropy response and in which data source the answer was found. We use the same notification approach for focused attacks.

Due to the small size of the data resources, any similarities would be flagged as low entropy. By flagging any exact matches or similar matches, the system also prevents trawling attacks or marginal guesswork attacks. In a trawling attack, the attacker knows the distribution of the possible answers. The attacker attempts to keep answering with the most popular responses until a weakness is exploited. Guessing entropy does not account for the attacker's willingness to move on to questions with higher probability answers (Bonneau et al., 2010). The marginal guesswork considers that an attacker may give up if the account cannot be exploited within a small sample of popular responses. Marginal guesswork threats can be accessed by the number of attempts necessary to determine the user's response. An overall average per question and per user can be calculated based on the security question and response.

6.4 Response Evaluation of Observation Attack

The paper assumes that an observation attack is a personalized modification of the guessing attack. An attacker seeks as much useful information as possible that would assist in impersonating the intended target. The information would consist of public, semi-private and private resources. In the proposed data acquisition engine, the user is assisted in checking similar resources that could be used against him or her to assist in the development of secure security question responses. The user is prompted to grant access to the data acquisition engine so that the user's data sources can be compared against individual question responses. Based on the data resources identified in the literature, the system attempts to acquire mother's maiden name, Facebook information and data found through a search engine query. Currently, data sources are limited but could easily be expanded. The system attempts to balance access to personal information without violating individual privacy and trust.

Beyond gathering known question distributions, a personalized attack will also seek out potential responses based on known and available information. Although the approach may be different from the guessing attack, the same mathematical model can be used. The distributions will be unique to each user due to known responses from the available data resources. Entropy will be calculated based on known distributions and identified information in data sources that conflict with or skew known distributions. If individual records exceed the NIST threshold for medium entropy, then a single match would still be considered medium security. Based on the type of data resources collected, we perform a Levenshtein test to determine similarity because gathered data sources may not have the same case or spacing

as the user's response. In summary, the process of information matching attempts to utilize an attacker's strategy to assist the user in selecting a high-entropy response.

6.5 Proofs and Assessment Measures

Figure 7 illustrates the criteria used in evaluating security questions. As shown in the figure, the criteria can be classified into two categories: The criteria that increase system security and the criteria that check the usability of the questions from the user's perspective.

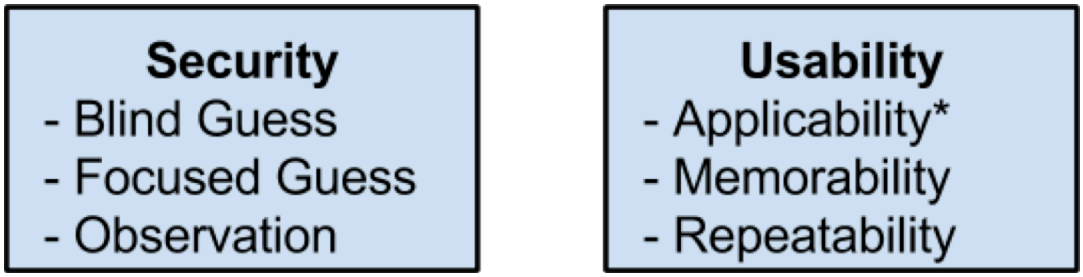


Figure 7 – Security question Evaluation Criteria

Security Analysis Proofs

The proof of the correctness of the model in evaluating the security of the question and answer pairings was done via four methods outlined by Bonneau et al. (2010). The authors documented a study on statistical attacks for names as a response to personal knowledge questions. The first method utilized Shannon (1948) entropy to determine the strength of a user's answer. The second method utilized guessing entropy, which was introduced by Massey 1994) and later named and further evaluated by Cachin (1997). Next, we calculated the marginal guesswork algorithm introduced by Pilam (2000). Finally, we implemented the marginal success rate, adapted from Boztas (1999) and outlined by Bonneau et al. (2010), to determine the success rate after a number of guesses [Appendix A]. Users in the experimental group will be notified of the strength of their responses. Responses with low entropy or high focused attack risk, in the experimental group, must be replaced by selecting new question and answer pairings. The key function of the data acquisition engine is the collection and identification of the entropy of user responses based on the gathered information. The goal of the outlined system is to create a secure answer distribution through high-entropy answers.

Usability Analysis

The usability of the system must be considered because the paper outlines methods to increase security that may impede usability. There is a tension between security and usability because an increase in one negatively affects the other

(Nicholson et al, 2012). The ISO defines three distinct aspects of usability – effectiveness, efficiency and satisfaction – whereas Bevan (1995) distinguishes two approaches to achieving usability – ease of use and the ability to use the product for its intended purpose. These two categories are often grouped into subjective and objective measurements (Nielsen and Leavy, 1994). Furthermore, Shakel (1991) defined usability as "the capability to be used by humans easily and effectively" (pg. 24). The challenge for usability is a general concept that cannot be measured, but individual parameters can be measured (Nielson, 1993). In addition to the overall usability constructs, Just (2004) suggested three usability constructs specific to security questions: applicability (subjective), memorability (objective), and repeatability (subject/objective).

Security questions must be clear and pertinent to the participant because irrelevant questions only heighten the disparity between security and usability. When a user selects or provides his or her own questions, we propose the applicability measure will be met. This approach is supported by Just (2004). Applicability in relation to the data acquisition engine's inputs is critical for properly generating an accurate assessment of the question and answer pairing (*security metric*). User participation in social media, and their overall electronic footprint, will not only help determine the security of the individual's question/answer pairings but have an effect on other participants. The information gathered from one individual may be used against others for focused attacks. During the post-experiment survey, users will be asked about alternative sources of information that may not have been included in the data acquisition engine. Additionally, users will be asked whether and where their responses could be found. The survey question helps identify new sources of information for the data acquisition engine and encourages participants in the future to be cognizant of answers that are known in other systems or by other people.

Question design must consider not only security and applicability but also the ability for the user to remember their response. Users must be able to recall their responses exactly. Some current implementations of security questions are not case-sensitive. The memorability test compares supplied responses with a second response to the same question over a defined period. Studies have evaluated the memorability of periods including 14 days (Bunnell et al., 1997), 60 days (Schecter et al., 2009) and 90 days (Zviran and Haga, 1990). In addition to a flexible time frame available through the web-based model, the proposed testing environment will be able to test memorability of the responses in situations in which previous studies have relied on self-assessments and blind paper and pencil tests [Just and Aspinall, 2004]. Furthermore, the use of an information system modeled after real-world security question systems will be more realistic than pen and paper testing.

The usability parameter examines the repeatability of a user's answers. Memorability can be affected by changing answers over time, which is measured by repeatability. Repeatability is achieved if the user is able to supply the correct

responses over a period of time and intervals. The survey will ask participants whether their responses are both memorable and repeatable. An additional question on the post-experiment survey will ask participants whether they found the experimental user interface usable.

Privacy / Trust Analysis

Privacy and trust are key components in properly evaluating our model. Privacy entails keeping information within the system's defined boundaries. When information is released either on purpose, by accidents or through a malicious act, data leakage occurs (Chen et al., 2009). Users must be willing to grant access to their social networking information and answer questions similar to "real-world" systems. To improve trust and privacy, we intend to articulate the purpose of the presented model including the declaration that all information will be both anonymous and secure.

With the collection and access of personal information, we have the responsibility to care for and maintain the data to ensure user privacy. Smith et al. (1996) outlined a validation instrument that measured user concerns concerning organizational information privacy. The outputs of the measurement were four areas of concern that were presented for the IS community to address. In the following statements, we have attempted to explain the concern relative to the presented model. First, the system must prevent unauthorized access to an individual's and to the group's information. Second, we will prevent unauthorized secondary use by not sharing the data to outside parties and following a well-documented chain of access to the information. Third, we will ensure users can fix and address any errors in the collection system via either automated error correction or access to a messaging system to notify the administrator of any issues. The final concern is collection of the data that are pertinent to this paper, because information collected for the data acquisition engine must be solely focused on improving security questions. Information collection will be limited to data that will be used to assist the model. Any additional information that is not related but is accessible through social media, public data sources or search engines will not be collected. Additionally, the proposed model must be evaluated on a consistent and regular basis. Regular security and privacy checks can ensure no information is revealed through participation in the model. Due to the nature of the proposed system, data leakage could violate a user's privacy or trust in security question systems.

To avoid affecting the privacy and trust constructs, the study limits the amount of information collected on a specific individual. Instead of accessing multiple social networks, only Facebook is used. Although not all participants will have an active Facebook account, through the post-survey, the goal is to identify users who were unwilling to share their account information. The paper will attempt to limit collected information while attempting to avoid affecting the

data acquisition engine's security metric. When the user verifies their Facebook account information during model testing, the test will not be anonymous. The name will be shown to the user but personal identifying information will not be stored. In the post-survey, participants will be asked whether they felt their privacy was violated and whether they trusted the system. If the participant felt their privacy or trust was violated, the survey will request an explanation. The proposed research model will attempt to balance security, usability and trust.

It is important to note the surveys scales used to measure security, usability, and privacy/trust include Likert-type scales (strongly agree to strongly disagree), category scales (class ranking and ordering) and open text fields. Likert-type scales are one of the most popular approaches to capturing data from participants (Kapstein et al., 2010). Tullis and Albert (2008) suggested Likert-type scales are a very efficient means for collecting participant data including the evaluation of experience and attitudes for usability evaluation. Challenges surround the evaluation of Likert-type scales because the data provided is ordinal. The distance between strongly agree and agree cannot be determined (Robertson, 2012). For ordinal data, a nonparametric statistical test must be used, although the tests lack power. Robertson recommends the reporting of the mode of Likert-scale data due to the ordinal (not interval) data. When using Likert-type scales, prudent analysis is strongly advised. To avoid the issues of participants responding in a consistent and uniform response, some questions are reversed coded. Additional scales are included to evaluate responses on Likert-type scales and to capture data to evaluate security, usability and privacy/trust.

7. Research Limitations

There are threats to validity that may undermine the goals of this research. The validity threats, internal, external, statistical and construct, are considered to limit concerns about the ability to conduct the experiment effectively (Creswell, 2009; Cook and Campbell, 1979). By addressing validity, the paper aims to ensure that any identified effects are caused by the intervention and not by other factors. Internal validity is delineated by participant threats, the experimental treatment, and the tools used for the experiment. For this paper, based on the sample population and experiment design, participant threats include history of security question use, maturation of the data available for security metric evaluation, and selection of the individuals for the control group. Experimental treatment validity threats include the diffusion of the treatment across a particular campus or group and resentful demoralization from withholding the security metric. Validity threats for the experiment's web-based tools include testing of the system and similar instrumentation. External validity threats include participant selection, setting and history. Statistical and construct threats remain possible and will be further examined after an initial sample of data is collected.

8. Further Research Directions: Refinement and Implementation of the Model

This section discusses the proposed plan to refine the security question model discussed earlier and to prove its correctness.

8.1 Refinement of the Model

The first research objective is the evaluation and refinement of the data acquisition component of the security question model. This data acquisition component contains the data sources and methodology designed to assess the security of user responses. This model will describe the key security features that will be applied to each user's response. Model refinement will include addition of data sources, modification of the security metric based upon responses and monitoring response time of the system to avoid dramatically affecting usability. To create an implementable model that retains security, usability and privacy, the following must exist:

- Question Selection: The model should offer various question options for users including the ability to add new questions. The model should be able to perform some initial identification of poorly crafted questions.
- Security Metric: The model should provide a security metric to the user. The notification will inform the user of the security of their response and potential data sources that contain their response.
- Data sources: The model should continually seek new data sources as new potential threats emerge through traditional and covert channels. Additionally, data sources must be vetted for accuracy.
- User Experience: The model should create a quality user experience that encourages and rewards the participant to create secure responses. Users should be able to contribute suggestions and feedback to enhance the process.
- Performance Criteria (concerning Usability): The performance of the model must be monitored for any actual or potential effect on usability. The model must be able to process the user input and output the appropriate security metric within a reasonable amount of time. If the process takes too long, users will be unlikely to follow the suggestions and may avoid interacting with the system. The model should monitor users exiting before completion.

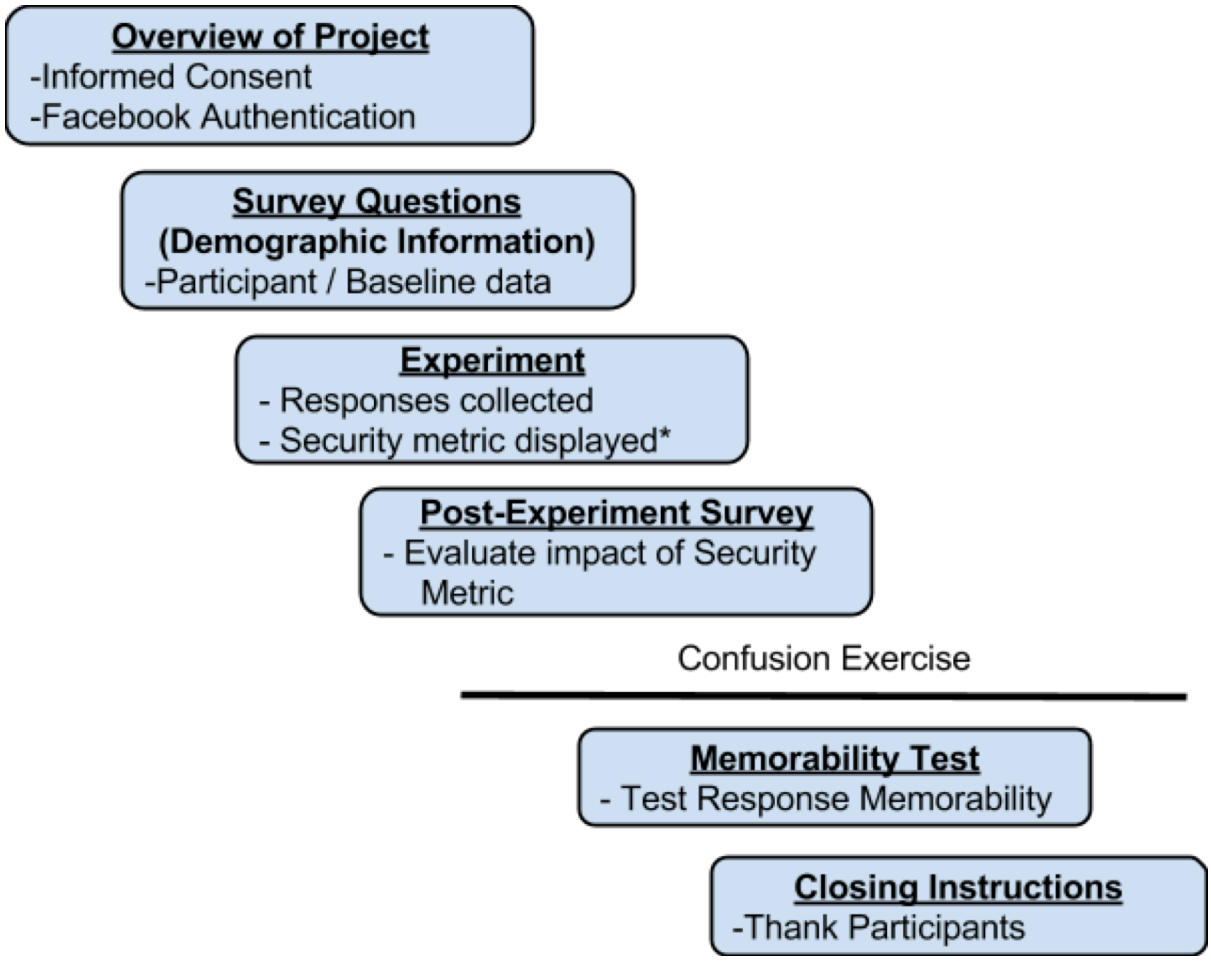
Evaluating the accuracy of the security metric, system usability and the users' overall perception of privacy and trust, the proofs must show that the security metrics generated by the system are correct and that users are responding by improving their responses. The system must prevent blind guess, focused guesses and observations. The proofs must also show that usability and privacy are not

affected by the implementation of the model. Additionally, the model must be reviewed to ensure that new threats have not emerged.

The proof of correction will include formal, vulnerability, usability and privacy analysis. The formal analysis should review the system as a whole for potential weaknesses and the possibility of unexpected attacks in the overall design. The vulnerability analysis should review which attack would be most likely and what is the threat level associated with the attack. Usability should determine the applicability, memorability and repeatability of the system. The privacy analysis will determine whether the model violates or negatively affects user trust and privacy.

8.2 Model Implementation

Figure 8 depicts the steps involved in evaluating the proposed models.



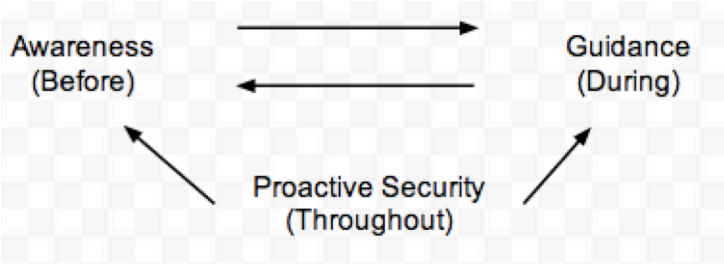


Figure 8 – Proposed Testing Methodology

9. Conclusion

The goal for both the user and the host system is to seek assurance that security questions as a secondary form of authentication are secure and that users have a positive perspective on the usability of the questions. In this paper, we proposed two models that can be used in classrooms to discuss issues related to security questions. The models enhance security while balancing usability, privacy and trust for authentication using security questions. If the proposed models were used for (1) balancing the factors that affect response usability and (2) analyzing responses for security strength, the models would significantly affect the use of security questions in mitigating security threats and increasing user satisfaction with this authentication method.

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LEVERAGING SPREADSHEET CAPABILITIES IN PRINCIPLES OF ACCOUNTING COURSES

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ABSTRACT

Spreadsheets are the most widely used financial software application (Ansari & Block, 2008) and are used extensively by companies to support business operations (Baxter, 2006). Familiar and readily available spreadsheet programs for accounting practice, such as Excel, are also effective in accounting education as a pedagogical aid, a skill-building utility, a platform for designing and presenting teaching materials, and a means to solve complex problems that are difficult to grasp in a more conceptual environment. The spreadsheet interface is an ideal environment to help students visualize integrated concepts through large displays of information. The inherent tools and functions of spreadsheet software enable students to manipulate quantitative data to produce content-related results while simultaneously developing highly-valued computer-literacy skills. This paper describes assignments developed specifically for novice business students to demonstrate how spreadsheets might enhance teaching and learning in a Principles of Accounting course sequence.

Keywords: Spreadsheet, Excel, accounting principles, computer literacy, accounting education

INTRODUCTION

Spreadsheet software is ubiquitous in the business environment, an example of what Chickering and Ehrmann (1996) called worldware: software applications already widely available and used outside educational settings. Microsoft Excel has become a *de facto* standard among business professionals worldwide (Bertheussen, 2014). Knowing how to use spreadsheets effectively is a valued asset in business (Hess, 2005) and is particularly critical for accounting practice. The American Institute of Certified Public Accountants (AICPA) and the International Accounting Education Standards Board (IAESB) identified spreadsheet technology as a key information technology competency for accounting professionals (AICPA, 1999; IAESB, 2007).

To prepare graduates for the workforce, spreadsheet technology should be prominent in post-secondary accounting education. Spreadsheet programs such as Excel can serve as a pedagogical aid, a skill-building utility, a platform for designing and presenting teaching materials, and a means to solve complex problems that are difficult to grasp in a more conceptual environment (IAESB, 2007). Course materials can be integrated into spreadsheets, and spreadsheet tasks can be embedded in course-related problems. In either case, spreadsheets can help students visualize links between the underlying concepts of the course materials and the applied aspects of particular problems (Ahmed, 2008).

Not only are spreadsheets used as pedagogical tools to deliver content, but they can also be incorporated into accounting courses to help students develop highly valued computer-literacy skills. Hands-on manipulation of data within a spreadsheet environment teaches students to use a spreadsheet as an analytical tool. Real-world templates allow students to gain basic spreadsheet experience through assignment preparation (Blayney, 1998). These templates are models of the applications and reports that students will ultimately be expected to produce on their own (Loraas & Mueller, 2008).

Finally, spreadsheets can be programmed to generate formative feedback. Educational research indicates that formative feedback can engage and motivate students and help them identify their strengths and weaknesses, reflect on their performance, improve their study skills, and increase their level of achievement (Aisbitt & Sangster, 2005; Evans, 2013; Halabi, 2006; Lewis & Sewell, 2007). Formative feedback guides students through the learning process by informing them about the accuracy of their responses as they work. This timely feedback is targeted toward improving both the process and outcome of problem-solving activities and is critical to student success in Principles of Accounting courses. (Bertheussen, 2014). Providing formative feedback using an answer-until-correct approach helps students acquire knowledge, reach higher levels of learning, and enhance retention (Lehman & Herring, 2003).

Spreadsheets are particularly useful learning tools because they give

users control over almost all functionality (Maddux, Johnson, & Willis, 1997). At the most basic level, students need to understand how spreadsheets work and how they are used to support business processes or solve business problems (Walters & Pergola, 2012). Burnett (2003) reported that at least one major university determined that problem solving using spreadsheets was important enough to necessitate their coverage in core accounting courses.

Problem statement

Principles of Accounting I and II comprise an introductory sequence that is required of almost all undergraduate business majors. For many students, these classes provide their first exposure to financial recording, reporting, and analysis. The integrated and form-driven nature of the accounting discipline and the continuous manipulation of mathematical data often prove daunting to novice learners (Sargent, et al., 2011).

While publishers' homework management systems offer technology-driven content delivery methods that help students practice with forms and data, their entry formats are often prescriptive, precluding students from committing errors they might otherwise make on paper. For example, one publisher acknowledges "a need for a less leading response system for journal entries and financial statements that discourages over-reliance on the system" which the company is currently attempting to address (Warren, et al. 2015). Also, the output from these online activities might not visually match what users are likely see in actual accounting practice.

Alternatively, output from commercial accounting packages (e.g., QuickBooks) and web-based financial reporting sites (e.g., Google Finance) allow students to see results as they appear in actual practice. However, these programs are limited for pedagogical purposes because they tend to generate results without necessarily showing the steps involved in the process.

Proposed solution

Introductory accounting students can benefit from opportunities to explore accounting concepts in an application that both supports the design of professional, real-world accounting forms and that is equipped to map quantitative relationships. Spreadsheet programs offer these capabilities and can be an effective interface for teaching and learning accounting concepts and processes. The purpose of this paper is to provide examples of spreadsheet templates that the literature suggests can be beneficial to students in introductory accounting courses.

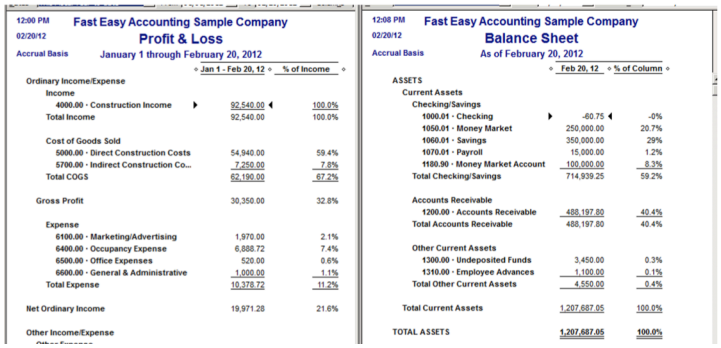
METHODOLOGY

Because introductory accounting is a format-driven discipline whose processes are well suited for spreadsheet applications, two instructors explored ways to create unique student activities and delivery methodologies by designing

spreadsheet problems in which students gather external information, record and manipulate data, and track processes for arriving at final results. A key strategy in these interactive models is to demonstrate how input impacts output. Students do not develop the templates at this introductory level; they are only are required to locate input data and use the templates to see how new numbers impact current results.

Each instructor developed a spreadsheet-based problem for the Principles of Accounting course sequence. The first problem is an accounting cycle assignment for Principles of Accounting I that incorporates formatting and functionality features to design forms, organize data, and provide student feedback. In this assignment, course materials are integrated into spreadsheets, resulting in an interactive, formative learning experience. The second problem is a hands-on investment analysis activity for Principles of Accounting II that requires students to select stocks and track portfolio performance over time. In this assignment, spreadsheet tasks are embedded within a course-related problem.

The first step was to identify samples of reports from commercial accounting packages and investment websites. These samples, as shown in Figures 1 and 2, can be presented in class so that students can visualize the actual output they will produce using the spreadsheet templates.



12:00 PM — Fast Easy Accounting Sample Company
02/20/12 — Profit & Loss
Accrual Basis — January 1 through February 20, 2012

	Jan 1 - Feb 20, 12	% of Income
Ordinary Income/Expense		
Income		
4000.00 · Construction Income	92,540.00	100.0%
Total Income	92,540.00	100.0%
Cost of Goods Sold		
5000.00 · Direct Construction Costs	54,940.00	59.4%
5700.00 · Indirect Construction Co...	7,250.00	7.8%
Total COGS	62,190.00	67.2%
Gross Profit	30,350.00	32.8%
Expense		
6100.00 · Marketing/Advertising	1,970.00	2.1%
6400.00 · Occupancy Expense	6,888.72	7.4%
6500.00 · Office Expenses	520.00	0.6%
6600.00 · General & Administrative	1,000.00	1.1%
Total Expense	10,378.72	11.2%
Net Ordinary Income	19,971.28	21.6%
Other Income/Expense		

12:08 PM — Fast Easy Accounting Sample Company
02/20/12 — Balance Sheet
Accrual Basis — As of February 20, 2012

	Feb 20, 12	% of Column
ASSETS		
Current Assets		
Checking/Savings		
1000.01 · Checking	-60.75	-0%
1050.01 · Money Market	250,000.00	20.7%
1060.01 · Savings	350,000.00	29%
1070.01 · Payroll	15,000.00	1.2%
1100.90 · Money Market Account	100,000.00	8.3%
Total Checking/Savings	714,939.25	59.2%
Accounts Receivable		
1200.00 · Accounts Receivable	488,197.80	40.4%
Total Accounts Receivable	488,197.80	40.4%
Other Current Assets		
1300.00 · Undeposited Funds	3,450.00	0.3%
1310.00 · Employee Advances	1,100.00	0.1%
Total Other Current Assets	4,550.00	0.4%
Total Current Assets	1,207,687.05	100.0%
TOTAL ASSETS	1,207,687.05	100.0%

Figure 1. Partial financial statements generated using QuickBooks accounting software.

Figure 2. Sample investment portfolio at a point in time generated by Google Finance.

The next step was to design ways within the spreadsheet templates to take students through the analytical processes involved in producing these commercial reports. Accounting forms were developed for data entry and display. Formulas, functions, and macros were written to map relationships among data, generate customized feedback for students, allow students to format input, and enable unique navigational and layout options. The resulting spreadsheet templates are sequential, dynamic, and interactive.

The efficacy of this approach is that it guides novice students through processes that culminate in output that is similar to real-world results. Because proactive instructional strategies can help users acquire more effective and efficient computer skills (Bhavanani et al., 2008), an additional benefit is that introductory accounting students can gain a working knowledge of spreadsheets that will serve them well in subsequent coursework and in their professions.

The discussion thus far supports the use of spreadsheets in Principles of Accounting courses and describes a process for implementation. The next section describes a spreadsheet-based accounting cycle problem for Principles of Accounting I. The third section describes an investment analysis problem designed in a spreadsheet for Principles of Accounting II. The fourth section discusses limitations of the study and suggests areas for further development.

ACCOUNTING CYCLE PROBLEM

The first assignment addresses the primary steps in the accounting cycle and the forms associated with submitting input: journal, ledgers, trial balance, and financial statements. These formats are unique to the accounting discipline. While course delivery systems such as Desire2Learn, Blackboard, and Moodle offer a robust menu of assessment question formats (e.g., multiple choice, matching, fill-in, graphical manipulation, and free-format text), the available question types do not meet the unique requirements of the longer, integrated, multi-format accounting

cycle problems that are typical of introductory accounting courses.

A spreadsheet is a blank canvas that is ideal for the efficient design of entry formats that are unique to accounting. Forms that are visually appealing, well organized, professional, and mathematically integrated can be developed and presented. Figure 3 shows examples of journal and account ledger entry forms, created using Microsoft Excel, that are appropriate for a basic accounting cycle problem.

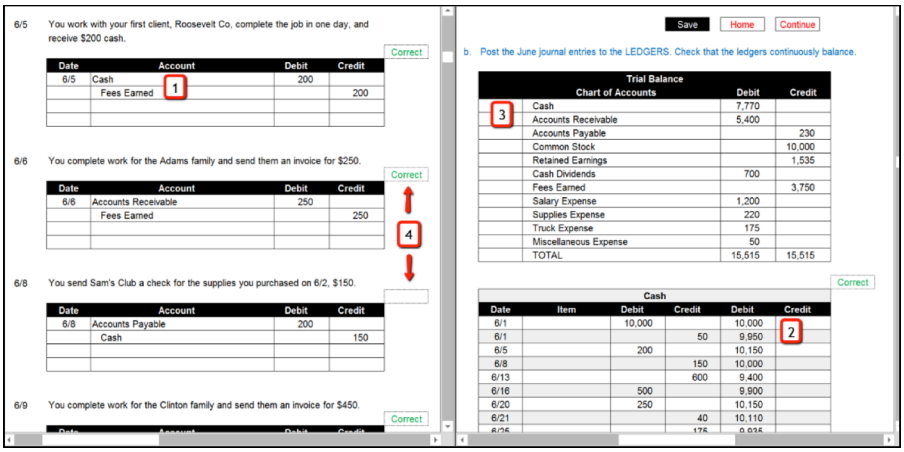


Figure 3. Sample accounting entry forms for completion of spreadsheet assignment.

A **journal** entry form (see #1 on the left side in Figure 3) is provided for each transaction in a layout that logistically matches the data in the transaction with an entry form to facilitate completion and minimize scrolling. On each journal form, more rows than are necessary are provided so that students are not overly guided in preparing the transaction.

The journal entry form shown in Figure 3 (#4) illustrates one type of formative feedback that spreadsheets are capable of providing to students. The approach is "all-or-nothing"; a green "Correct" appears only after the entire transaction has been properly completed; there is no partial credit. For example, because one of the amounts in the 6/8 journal entry in Figure 3 is incorrect, the transaction as a whole does not warrant a "Correct" indicator. Students must analyze their work to discover the change(s) required to arrive at the correct answer. The value of this process is that students are continually aware of any missteps as they progress. Knowing when and where errors arise in a long problem helps students focus on resolving them as they occur and ask targeted questions.

Respectively, Figures 4 and 5 show the student entry form and the corresponding hidden answer key for a single journal entry. Table 1 lists formulas used in the three-step process for determining when the two forms match (i.e., when the "Correct" indicator appears).

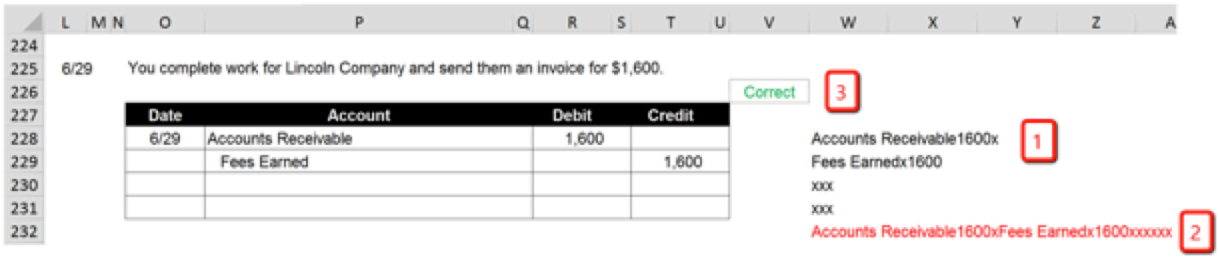


Figure 4. Sample journal entry form with formula output for determining correctness.

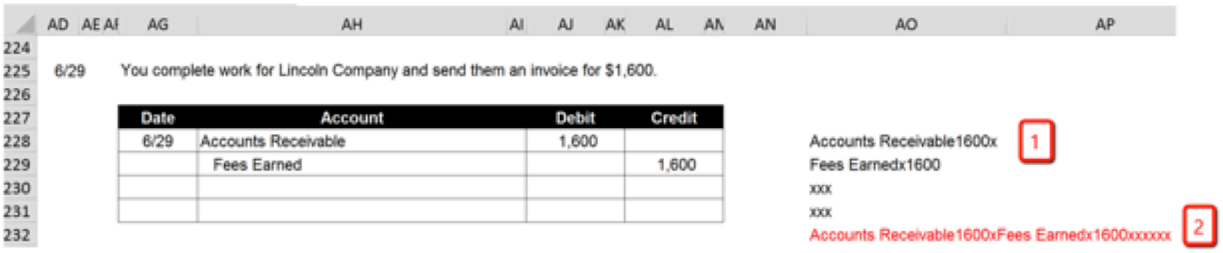


Figure 5. Answer key for sample journal entry form with formula output.

Table 1. Sequence of Formulas for Determining Whether a Journal Entry is "Correct".

Ref	Cell Output	Cell Formulas and Functions
1	The values in each row are concatenated to the right in columns W and AO.	=IF(TRIM(P228)="","x",TRIM(P228))&IF(R228="","x",R228)&IF(T228="","x",T228)
2	The concatenated values from #1 above are concatenated (W232 and AO232).	=W226&W227&W228&W229&W230&W231
3	The "Correct" indicator appears in cell V226 if W232=AO232.	=IF(W232=AO232,"Correct","")

In addition to providing feedback, spreadsheet functions are used to generate and format algorithmic versions of the problem so that each student receives an iteration with a unique data set. This feature is particularly useful for summative assessments (e.g., testing) because it reduces the possibility of student sharing. Figure 6 and the formulas in Table 2 show how a randomly determined amount within a designated range is generated and where that value is placed within a journal transaction.

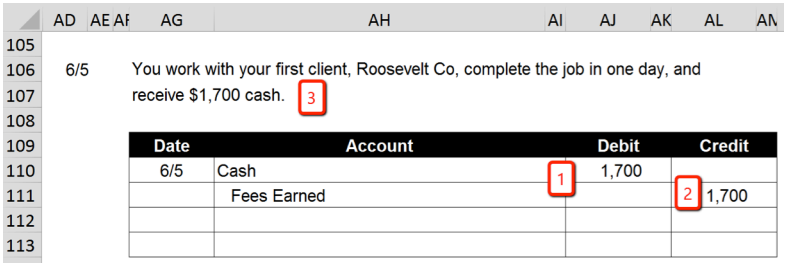


Figure 6. Sample journal entry form with algorithmically generated amounts.

Table 2. Sequence of Formulas for Embedding Algorithmically-Generated Values

Ref	Cell Output	Cell Formulas and Functions
1	The RANDBETWEEN function algorithmically generates a result for a specified range, as is shown in the following formula for the Cash debit amount in Figure 6. The ROUND function applied to it assures that the final two digits are zero. (Cell AJ110)	=ROUND(RANDBETWEEN(1500,2500),-2)
2	The Cash credit amount is set to equal the debit amount. (Cell AL111)	=AJ110
3	The randomly generated value is embedded in the transaction's narrative. (Cells AG106 and AG107)	="You work with your first client, Roosevelt Co, complete the job in one day, and receive $"&TEXT(AJ110,"#,###")&" cash."

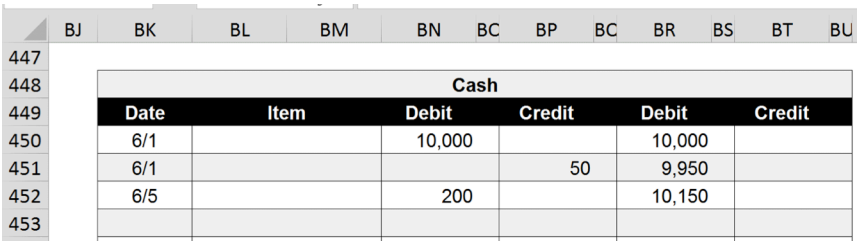
The algorithmic data generated in the journal transactions are then carried through the remainder of the integrated problem using a series of formulas.

A **ledger account** entry form (see #2 on the right side in Figure 3) provides one account for each item listed on the chart of accounts, and these accounts are listed vertically, beginning with *Cash*. Each ledger account includes more rows than are necessary so that students must determine what they need to complete.

The ledger form designed in the spreadsheet helps students maintain running account balances and see the impact of journal entries on these balances. The ledgers can serve multiple functions, depending on the preferences of the instructor and the learning goals for the assigned problem. As the semester goes by, the instructor might vary which amounts must be entered into the ledgers by students manually and which appear automatically as a result of formulas and functions. At the beginning of the course, when students are still learning the types of information that ledgers provide and how running balances are determined, they might

manually enter (a) the values from the journal into the first set of debit/credit columns and (b) the running total into one of the two balance columns. After a few experiences with this process, the instructor might assume that students understand how debit and credit entries impact the running balance. At this stage, formulas are used so that each manual posting to the ledger automatically updates the running balance. After the accounting cycle has been covered in its entirety and the instructor is confident that students grasp the posting process, any entries made to the journal automatically post to the ledgers, and the running balances update simultaneously. Spreadsheets can shorten the time spent copying and computing, in turn creating opportunities for achieving higher-level learning objectives (Borthick & Clark, 1986).

Figure 7 displays a ledger account form that uses formulas to update the balance column automatically in either column BR or column BT of an account ledger. The Cash ledger is used to illustrate cell locations. Table 3 displays the formulas used in the form in Figure 7.



	BJ	BK	BL	BM	BN	BC	BP	BC	BR	BS	BT	BU
447												
448		Cash										
449		Date	Item		Debit		Credit		Debit		Credit	
450		6/1			10,000				10,000			
451		6/1					50		9,950			
452		6/5			200				10,150			
453												

Figure 7. Sample ledger form with running debit balance that calculates using formulas.

Table 3. Sequence of Formulas for the Automatic Calculation of Ledger Account Balances

Cell Reference	**Formula**
BR450	=IF(AND(H702=1,BN450<>"",BP450=""),BN450,"")
BT450	=IF(AND(H702=1,BP450<>"",BN450=""),BP450,"")
BR451	=IF(H702<>1,"",IF(AND(BN451<>"",BP451<>""),"",IF(OR(AND(BR450 ="",BT450=""),AND(BP451="",BN451="")),"",IF(AND(BR450<>"",BN451>1),BR450+BN451,IF(AND(BR450<>"",BR450>=BP451),BR450-BP451,IF(AND(BT450<>"",BN451>BT450),BN451-BT450,""))))))
BT451	=IF(H702<>1,"",IF(AND(BN451<>"",BP451<>""),"",IF(OR(AND(BR450 ="",BT450=""),AND(BP451="",BN451="")),"",IF(AND(BT450<>"",BP451>1) ,BT450+BP451,IF(AND(BT450<>"",BT450>=BN451),BT450-BN451,IF(AND(BR450<>"",BP451>BR450),BP451-BR450,""))))))

The **trial balance** form is positioned just above the list of ledger accounts (see #3 on the right side in Figure 3). It is programmed by default to capture the final running balance in each of the ledger accounts and to calculate the respective totals of its debit and credit columns. As such, the trial balance form is a dynamic tool that students use to check their accuracy as they work, rather than another form to fill in by copying amounts from the ledgers. Seeing the amounts and respective totals change with each ledger entry reinforces the components of a trial balance and what its value is. However, the automatic entry feature can be turned off at the instructor's discretion.

Table 4. Sequence of Formulas for Completing the Trial Balance from Ledger Account Balances

Cell Output	**Cell Formulas and Functions**
Cash debit balance in the trial balance is determined by pulling in the last amount listed in the debit balance of the Cash ledger (which appears in rows BR450 through BR471)	=IF(BR450="","",INDEX(BR450:BR471,MATCH(9.99999999999999E+307,BR450:BR471)))
A similar formula is used for each account in the trial balance, referencing the respective rows of each account's ledger form.	
The debit balance column is totaled.	=SUM(BR433:BR443)
The credit balance column total formula is similar, using different cells references.	

Finally, the **financial statements** appear as students move through the multi-part sequence. They include the income statement, retained earnings statement, and balance sheet for the period. The spreadsheet is programmed to allow for three possible formatting options based on the desired level of rigor and instructor preference. The first provides the heading and accounts on the screen and only requires students to enter amounts in designated cells. The second requires students to enter the heading, account names, and amounts into designated cells; each entry box requires input. This second form is programmed to permit accounts and their corresponding amounts to be entered in a variety of correct orders. Figure 8 shows examples of these first two options for a balance sheet.

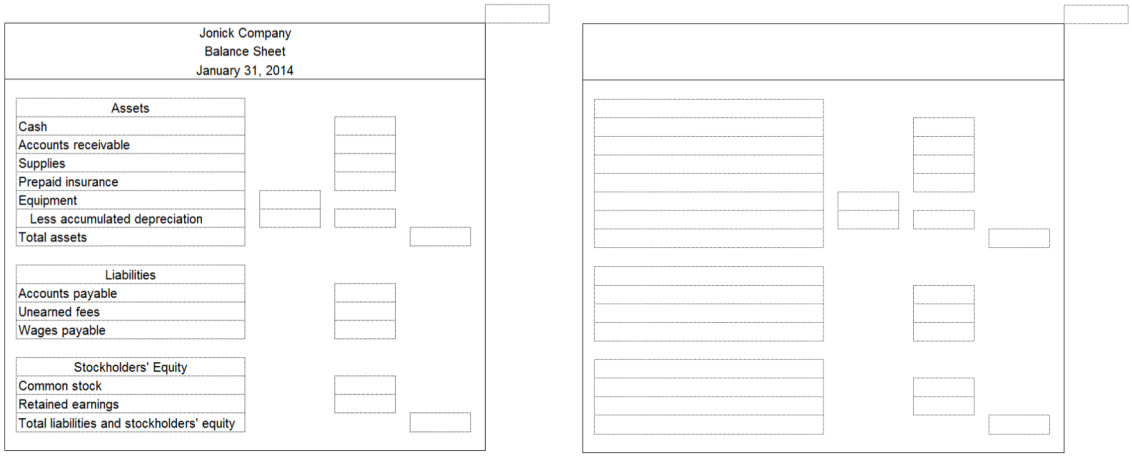


Figure 8. Two sample balance sheet entry forms with varying amounts of data provided.

These balance sheet entry forms are quite useful in the very early stages of learning financial statements. Students are provided with the exact number of rows, columns, and entry boxes they need to complete the activity. Students are visually prompted by the placement of input boxes within the form to make entries in the appropriate place at the appropriate time, and they have no space for additional but incorrect input. The forms themselves help guide students to the correct answers and familiarize them with these reports.

One of the criticisms of web-based homework management systems offered by accounting textbook publishers is that they follow these same form-driven models even for more advanced problems; as a result, assessment activities for financial statements are less challenging than the same problems on paper. Instructors often prefer a "blank page" electronic format to assess comprehension of financial statements by having students prepared them in more of a free-format style. The third option for presenting financial statements in this spreadsheet-based problem offers this capability, using a unique combination of layout and programming features. The entry form in Figure 9 is used to prepare a balance sheet with very limited guidance.

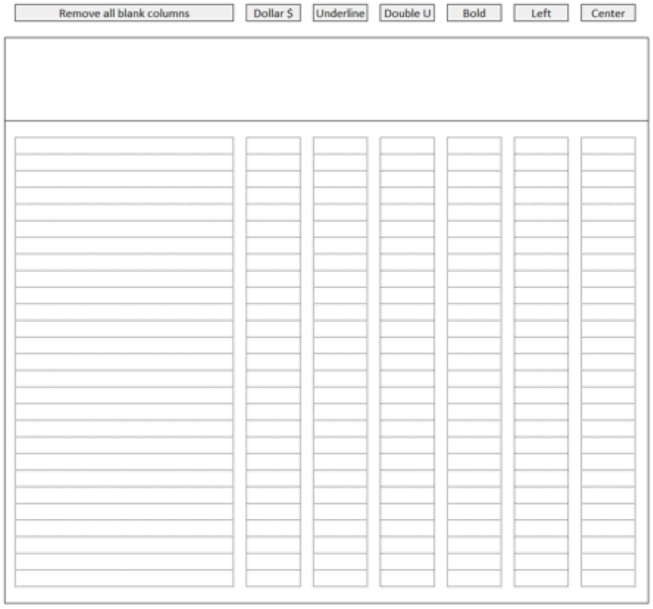


Figure 9. "Blank page" balance sheet input form provides more entry cells than are required.

This form includes five rows for the heading when only three are needed, six columns for numerical entries when a maximum of three is required, and many more rows than necessary. Other than cell borders to indicate where entries might be input, there are no indications of the type, location, or number of entries required. Stylistic formatting features such as underlining and dollar signs may be added by students, a feature not available in commercial homework management systems.

Figure 10 illustrates correctly completed versions of the "blank paper" style balance sheet. On the left is the work sheet version with all of the potential entry cells still visible. This format might be considered sufficient, but clicking the "Remove all blank columns" button converts the input into its final format, shown on the right. This functionality offers students a robust and less guided experience for completing the balance sheet, more closely resembling the challenge of preparing one on paper. The VBA (Visual Basic for Applications) coding to enable this functionality appears in Appendix A.

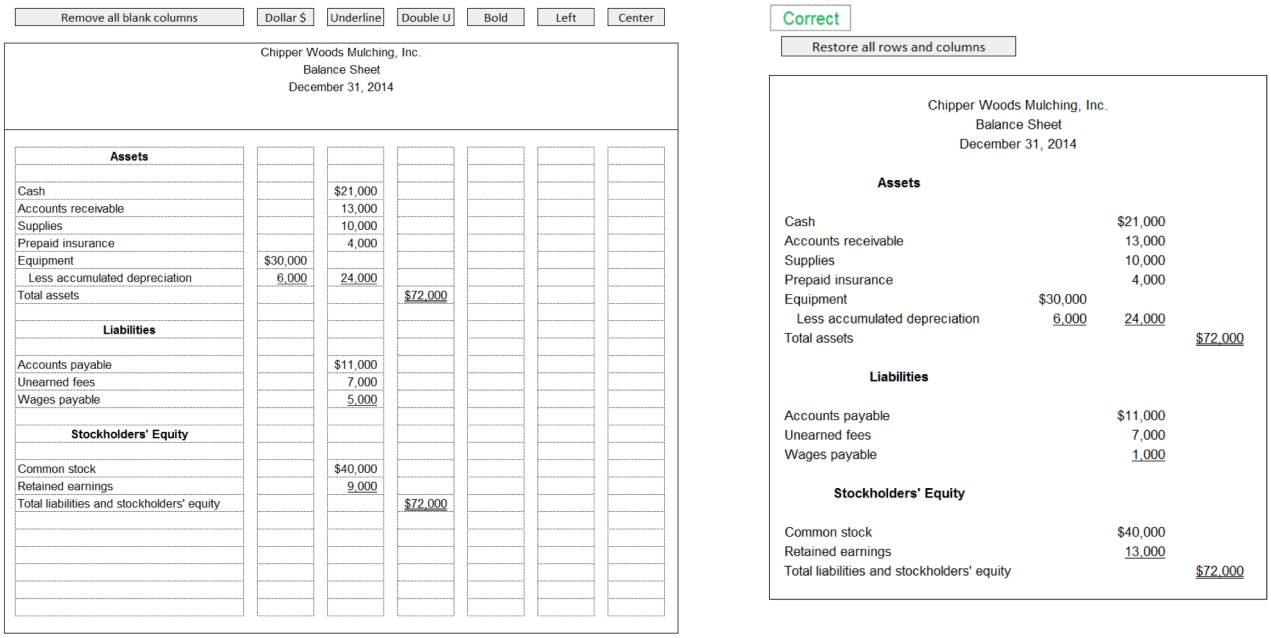
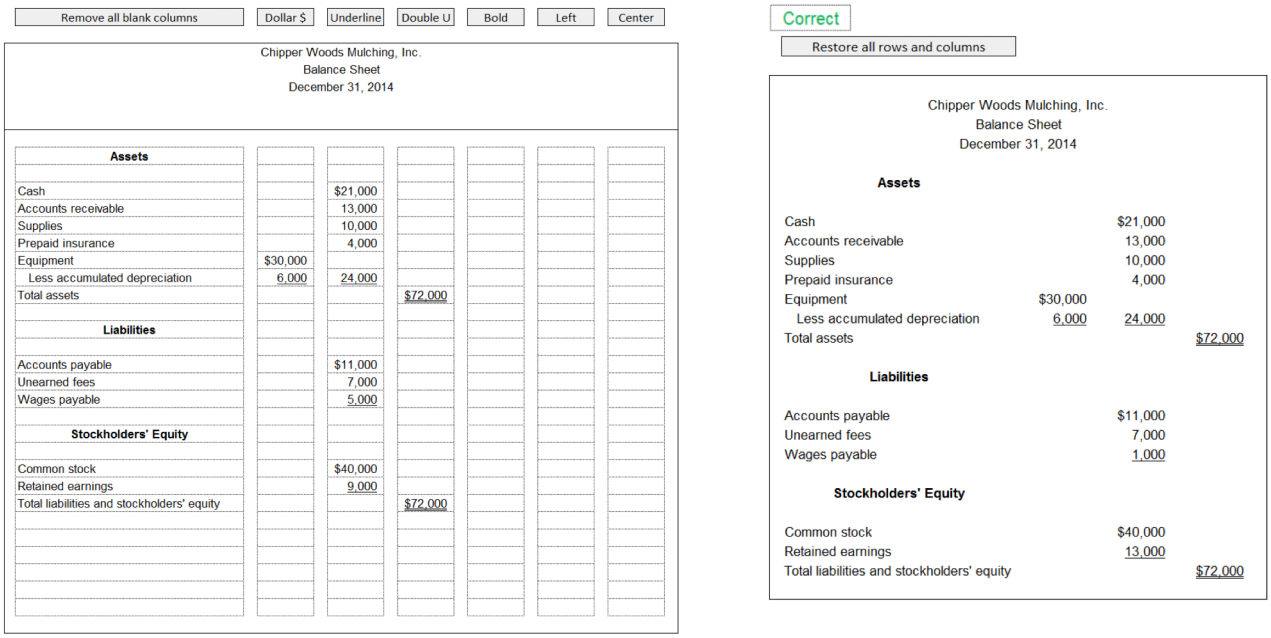


Figure 10. Completed balance sheet forms illustrate the formats before (left) and after (right) extra entry cells and gridlines are removed.

This collection of entry forms in an accounting cycle problem—the journal, ledger accounts, trial balance, and financial statements—must be well organized to be effective. Figure 3 not only provides examples of the design of accounting forms but also shows how these forms are laid out within the assignment using a split screen configuration that intentionally matches the data required for a task on the left to the task's entry boxes on the right. Forms and/or data that are not required for a given step are temporarily removed from view. As users complete a step, they click a button to advance to the next screen, which shows only the data and forms needed to complete the subsequent step. Scrollbars enable users to align information provided on the left side of the screen with input boxes on the right, allowing for ease of use and quick reference to required data. The VBA code that enables this split screen configuration appears in Appendix B.

The journal, ledger accounts, trial balance, and financial statements have been designed, programmed, and organized within the user-friendly, familiar environment of spreadsheet software. The templates offer accounting-style forms with varying levels of automation that can be activated or turned off based on different learning objectives and instructor preferences. The forms load immediately, and data entry results are instantaneous. These benefits exceed those of similarly-formatted large problems designed as web pages, such as those found in commercial course management systems for delivering discipline-specific content, applications that tend to have longer load and submission times. Ongoing feedback is generated as students engage in the assignment to guide, encourage, and inform learners as they progress.



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INVESTMENT ANALYSIS ACTIVITY

The second instructor offers extra credit opportunities in Principles of Accounting II through pre-formatted spreadsheets that target real-world applications. One such assignment provides students with a hypothetical dollar amount to invest and asks them to select five publicly-traded stocks they can purchase for this amount. Students track the performance of their selections over ten periods, compile the data collected in a spreadsheet template provided by the instructor, and analyze the performance of their portfolios.

Students begin by downloading a preformatted spreadsheet template and entering in rows three and four the names of the stocks they plan to purchase and track, the stocks' ticker symbols, and the number of shares purchased. Over the duration of the course, they record the date and the market price per share of each stock investment at ten different times. The spreadsheet automatically generates the total values of each stock, the total market portfolio value, and the portfolio gain or loss. It also populates the charts underneath, displaying graphic performances for the total portfolio and the individual stocks. Appendix C displays the formulas used in the template. Figure 11 is an example of the spreadsheet portion of the extra credit assignment (including the charts).

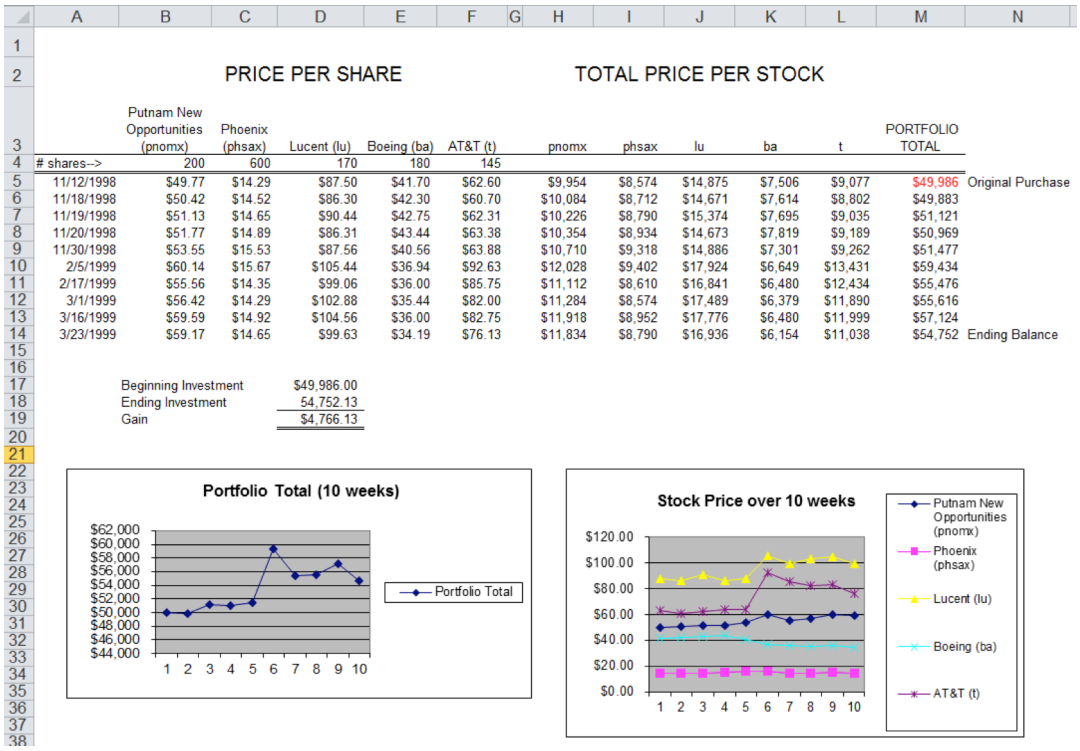

Figure 11. Completed spreadsheet for the investment portfolio assignment with data-dependent graphs.

This straightforward application not only introduces novice students to investments but also demonstrates the functionality of a spreadsheet. Through the layout designed by the instructor, students visually see the data required and the variables involved in achieving a solution to a content question. In addition, students who have had little or no practical experience with spreadsheets are able to see how their input impacts desired output. In this way, the spreadsheet portion of the assignment might be considered a dynamic version of static textbook example. A key difference between a static sample problem printed in a book and this exercise is that students, rather than a textbook author, provide the necessary data for the input.

The completion of the spreadsheet, however, is not the ultimate goal of the assignment. Spreadsheets provide an organization platform that students can then use to evaluate the performance of their portfolios. They must supplement their spreadsheets with an analysis that evaluates how their stocks performed in relation to the market as a whole, how each stock performed in relation to its industry, and how each stock performed in relation to its own history. Students learn how to investigate companies in real time and to demonstrate their comprehension of the materials presented in both accounting principles courses.

A significant body of research indicates that spreadsheet modeling promotes higher-level thinking and deeper, context-based learning (Blayney & Freeman, 2004; Lehman & Herring, 2003). Rao, Stenger, and Wu (1992) suggested that spreadsheets might be used "as an analysis tool to help students understand the relationships among variables and solve problems through model building. (p. 4)" While students in accounting principles courses might not yet possess the knowledge base or skill set to engage significantly in spreadsheet modeling, a starting point might be for them to prepare a relatively basic spreadsheet from scratch. For example, the investment portfolio assignment might be modified to provide only general instructions, but not an instructor-prepared template (see Figure 12).

INSTRUCTIONS:
Invest $50,000 in five stocks over the period of this course. You should track at least 10 dates.
Create a spreadsheet that includes your stock names, symbols, dates, # of shares and price per share.
Use formulas to total the market value of each stock, the market value of the complete portfolio, and
the percent of gain or loss on each date compared to the purchase price.
Create a graph based on your data to show the total value of your portfolio on each date.
Create a second graph based on your data to show the total value of each of your stock holdings on each date.
Express an opinion on the portfolio's performance.

Figure 12. Basic spreadsheet instructions for completion of the portfolio assignment.

Students would be required to design a spreadsheet that effectively displays the specified information and integrates formulas to summarize the data and display them graphically, similar to what is shown in Figure 11. The project could then be further expanded to include some basic programming in the design

requirements. A simple example might be to include a button that would automatically prompt a user for the date and number of shares purchased for each stock in a given row.

The investment analysis activity introduces students to the process of analyzing relationships among data and producing valuable numerical output. This assignment communicates to students in accounting principles classes that spreadsheets are a relevant tool in the accounting field.

LIMITATIONS AND AREAS FOR FURTHER DEVELOPMENT

The scope of this paper is limited to a discussion of the design of spreadsheet assignments that the literature suggests might benefit students in the Principles of Accounting course sequence. The efficacy of using these spreadsheets to enhance teaching and learning is not yet supported by empirical evidence.

Further study is required to determine whether using these spreadsheet assignments impacts student learning outcomes in accounting principles courses. Evidence such as spreadsheet assignment results, exam scores, final course grades, and GPAs should be collected from a large, robust sample of university students across various course sections taught by various instructors and analyzed. This type of empirical study would facilitate generalizations regarding the effectiveness of using spreadsheet assignments as a pedagogical tool.

CONCLUSION

Spreadsheets can be used to harness technology to deliver learning and assessment activities and maintain academic productivity in spite of diminishing resources (Blayney & Freeman, 2004). In the process, students are exposed to technology and spreadsheets in their introductory accounting courses. In addition, spreadsheets can provide immediate feedback (Henry, 2011) and individually customized learning experiences (Haytko, 2006) via quality technology that today's connected students expect.

This paper offers working examples of the way spreadsheets can be integrated into Principles of Accounting courses for functionality, design, instruction, and learning purposes by (a) familiarizing novice students with the software, (b) formatting unique accounting problem types, (c) offering timely and meaningful feedback to learners, (d) enhancing the quality of learning assessments and activities, and (e) providing students with opportunities for spreadsheet development. Actual implementation of these strategies in the classroom should be investigated further to reveal how well they promote student learning.

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OIL PRICE MOVEMENTS AND HOUSE PRICES IN THE STATE OF TEXAS

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ABSTRACT

This study examines the impact of oil price movements on the housing markets in the state of Texas. Prior evidence indicates that oil price does not always have a positive impact on the economic activities of oil producing states. We utilize a vector autoregressive framework to examine the impact of the WTI price on the house price in Texas for a pre-economic crisis period from 1990 to 2007 and a post-economic crisis period from 2008 to 2015. The variance decomposition results show that a shock to the WTI price explains house price variations of about nine percent in the pre-crisis period and about eleven percent in the post-crisis period. The impulse response results indicate that a shock to the WTI price results in a negative response in house prices, mainly in the post-crisis period. Overall, the results suggest that a rising oil market is not favorable for investment in the housing sector in Texas.

Keywords: Oil Price; Housing Market; Texas

I. INTRODUCTION

There is an extensive literature on the impact of oil price movements on overall economic activities [Hamilton (1983), Mork (1989), Hooker (1996), Ferderer (1996), Hamilton (1996), Hamilton and Herrera (2004) and Barsky and Kilian (2004)]. There is also evidence that oil price changes impact regional economic activities. For example, Iledare and Olatubi (2004) find that oil prices influence economic activities of the Gulf States, and Shekar et al. (2013) observe that oil price shocks impact economic activities of certain cities in the state of Texas. Although, most previous studies examine oil price and economic activities, it is not clear how the housing market is related to oil price. The literature on housing market is also extensive showing how housing market is influenced by external factors [Edelstein and Tsang (2007), Hwang and Quigley (2004), Miller and Peng (2006), Moench and Ng (2010), Nneji et al. (2012), Choudhury (2010), Leung (2004), Keuthe and Pede (2008), and Kim and Bhattacharya (2009)].

This study examines the impact of the West Texas Intermediate (WTI) oil price on the housing market in the state of Texas. (The housing prices utilized in this study are obtained from the Texas A&M Real Estate Center database, which is based on nearly fifty metropolitan MSL areas in the state of Texas.) Although it appears that, as a prominent oil-producing state, Texas benefits from rising oil prices, prior studies show mixed results on this topic. For example, Gaines (2015) shows that Texas housing market improves only when oil price is in an optimal range. A very high price or a very low oil price does not support housing growth. Engemann et al. (2011) observe that Texas economy experienced recessions around both negative and positive oil shocks. Since Texas has become a diversified economy over the years, it remains to be seen how oil price impacts its housing markets in recent years when compared to past years.

Our study is different from the previous studies in several ways. First, we investigate oil price and housing market data over a longer sample period from 1990 to 2015. Second, we investigate these data for periods separated by the 2007 economic crisis. Third, we utilize real data for housing and oil price adjusted by consumer price index and producer price index. Finally, we adjust for the stationarity in the data series and utilize a vector autoregressive (VAR) analysis.

We present our results from 1990 to 2015, with the sample period separated by the economic crisis. We classify the 1990-2007 period as a pre-economic crisis period characterized and the 2008-2015 period as a post-crisis period. The median real price of WTI reported in Table 1 of our study is $18.78 during 1990-2007 and $45.64 during 2008-2015. Following Gaines (2015), we expect house prices to exhibit different relationships with the oil price in the pre-crisis and post-crisis period.

Our results show that a shock in the WTI price explains future variations in the house prices in the state of Texas and that the variations are higher during the post-economic crisis period than during the pre-economic crisis period. The impulse

response results show that the impact of oil price on house prices is negative and pronounced through month 8, mainly during the post-economic crisis period.

The rest of the paper is organized as follows. Section II provides a review of literature on oil price shocks and housing markets, and section III describes the data and sample. The empirical results are provided in section IV followed by concluding remarks in the last section.

II. LITERATURE REVIEW

A. Impact of Oil Price Shocks

In a seminal study, Hamilton (1983) observes that all but one of the U.S. recessions since World War II were preceded by a dramatic increase in the price of crude petroleum. Mork (1989) finds that oil price increases have a stronger impact on economic activity than oil price decreases. Hooker (1996) shows that the impact of oil shocks does not hold for data that extend to 1990s. However, Ferderer (1996) and Hamilton (1996), and more recently Hamilton and Herrera (2004) and Barsky and Kilian (2004) show that oil price shocks have asymmetric effects on economic activities.

While the above studies examine the impact of oil price at the national level, a few studies [Brown and Yucel (1995), Penn (2006), and Iledare and Olatubi (2004), and Engemann et al. (2011)] focus on state economies. Brown and Yucel (1995) argue that fluctuation in energy prices was a major reason for differences in regional economic performance during the late 1970s and early 1980s. Rising oil prices stimulate economic growth in the oil-producing regions and slow down economic growth in the oil-importing regions. Penn (2006) examines the effect of oil price changes on the states of the Eighth Federal Reserve District and finds that some states are more sensitive to oil price changes than others.

According to Engemann et al. (2011), the effects of oil price on economic activities can vary across states. Their data also show that the economic activities in Texas had a distinctly idiosyncratic relationship with oil prices. For example, Texas experienced a recession following the negative price shocks of 1986, and another recession following the positive price shocks of 1980-1981.

Iledare and Olatubi (2004) find that the economic performance of Gulf States is directly affected by changes in petroleum prices and that the impact varies across the states in the Gulf coast. In their study, the highest unemployment rates elasticity with respect to petroleum prices occurred in Alabama while the lowest elasticity occurred in Texas. The impulse response functions also reveal varying degrees of adjustments across the Gulf States.

More recently, a study by Shekar et al. (2013) examines how oil price shocks

impact unemployment rates in several cities of Texas. They find that unemployment rates in the bigger cities such as Austin, Dallas, and Houston, are not related to oil price. Unemployment rates in smaller cities especially near the border (e.g., Laredo) are influenced significantly by movements in oil price.

B. Determinants of Housing Price

Real estate represents a major portion of most people's wealth especially in the United States. A review of the literature reveals that the following are key factors driving the real estate market: interest rates; demographics such as income, migration patterns and population growth; overall health of the economy measured by indicators such as GDP, employment data, manufacturing activity and the rate of inflation; and attractiveness of real estate to investors.

Early research focuses primarily on the relationship between housing prices and interest rates. In one of the earliest studies, Abraham and Henderson (1992) find that interest rates and employment account for less than half of housing price changes in the U.S. Adams and Fuss (2010) distinguish the impact of short-term and long-term interest rates on housing prices, and conclude that short-term rates adversely affect the demand for houses as they affect mortgage rates and the cost of financing for real estate construction. Additionally, rising long-term rates adversely affect real estate investments inducing switching capital from less attractive housing investments. Iacoviello and Minetti (2003) observe that, over time, housing prices have become more sensitive to interest rate changes in the European counties due to ease in securing mortgages.

Several recent papers examine the relationships between housing prices and macroeconomic factors other than interest rates. Lastrapes (2002), utilizing an autoregressive model, attributes short-term increases in house prices to positive money shocks. Brunnermier and Juliard (2008) argue that inflation is more important than interest rates in impacting commercial real estate price-rent ratios. Belratti and Morana (2009) find that 40 percent of the variations in house prices in the G-7 countries are caused by global economic shocks. Adams and Fuss (2010) indicate that industrial production, unemployment levels and money supply influence housing prices.

A number of recent studies provide evidence on the relationships between house prices and macro-economic indicators including interest rates. For example, Nnejiet et al. (2012) employ a three-state Markov switching nonlinear model utilizing, as the dependent variable, the quarterly change in house prices, and as independent variables short-term interest rate, term spread, inflation rate, and gross domestic product. They find that there are three distinct regimes in the housing market, namely steady-state, boom, and crash regimes, and conclude that changes in the selected independent variables impact housing prices in the steady-state and boom regimes only. During housing busts, the housing prices are not

related to the independent variables. In his study of the UK housing market, Pettinger (2015) observes housing prices are impacted by economic growth, unemployment, interest rates, consumer confidence, mortgage availability, supply, house price to earnings ratio, and several geographic factors.

C. Impact of oil prices on housing prices

There are only a few research studies that examine the relationship between energy and housing prices. Gaines (2015) concludes that the relationship between home prices in Texas and the WTI price depends on the levels of oil price. He finds a positive correlation when oil prices range from $30 to $110 a barrel, and a negative correlation when oil prices are less than $30 a barrel or more than $110 a barrel. In his study, other indicators of housing performance such as housing permits and home sales also exhibit positive correlations with the WTI price within an optimal oil price range. Anari and Gilliland (2014) develop a real estate model that shows a strong correlation between oil prices and Texas rural land prices, both statewide and by region. Molloy and Shan (2010) analyze the impact of gasoline prices on several household locations. Their findings show that housing supply in most areas is elastic enough for gas prices to affect the quantity of housing but not the price.

III. DATA

In this study, we examine housing prices in Texas in relation to oil price. We use monthly data from January 1990 to April 2015. The median house prices are obtained from the Texas A&M University's Real Estate Center website (http://recenter.tamu.edu/data). The housing prices cover nearly 50 Texas metropolitan MLS areas in Texas. Oil price data are collected from the Energy Information Administration's website (http://www.eia.gov/). The producer price index and the consumer price index data are collected from the Bureau of Labor Statistics (US Department of Labor website).

We examine the WTI price and median housing price in Texas in real terms. The real WTI price is computed as the nominal price of the WTI divided by the producer price index for all commodities. The real housing price is the median home price divided by the consumer price index.

IV. Results

A. Descriptive Statistics

Table 1 reports descriptive statistics of the WTI price and house prices in Texas. The data in Panel A show that the mean and median real price of WTI from 1990 to 2015 were $28.36 per barrel and $23.40 per barrel, respectively. For the same period, the mean and median home prices in Texas were $78,110 and $79,440, respectively.

Table 1

Descriptive statistics on oil price and median house price in Texas for the sample period (January 1990 – April 2015), pre-crisis period (January 1990 – December 2007), and post-crisis period (January 2008 – April 2015).

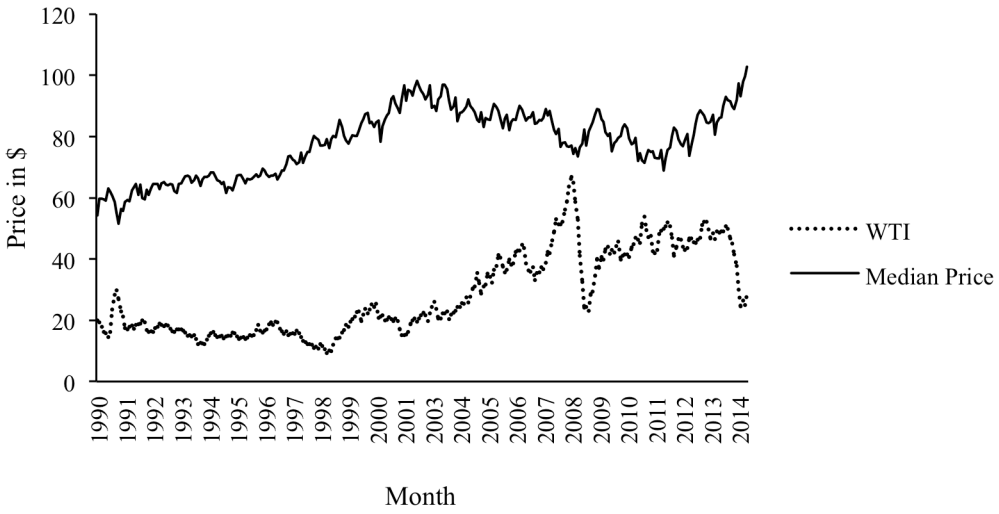
Variables	N	Mean	Median	SD	Min	Max
Panel A			Entire Period (1990 - 2015)			
Real WTI Price ($)	304	28.36	22.72	13.69	9.24	66.77
Median House Price (thousands of $)	304	78.11	79.44	10.86	51.46	102.88
Panel B			Pre-Crisis Period (1990 - 2007)			
Real WTI Price ($)	216	21.79	18.78	9.11	9.24	52.94
Median House Price (thousands of $)	216	76.72	78.87	11.83	51.46	98.09
Panel C			Post-Crisis Period (2008 - 2015)			
Real WTI Price ($)	88	44.50	45.64	8.75	23.09	66.77
Median House Price (thousands of $)	88	81.51	80.21	6.92	68.81	102.88

Panel B reports descriptive data for the pre-crisis period, from 1990 to 2007. The data for the pre-crisis period show that the mean and median real prices of WTI were $21.79 per barrel and $18.78 per barrel, respectively. These prices are slightly below that of the entire sample period. The mean and median real house prices are $76,720 and $78,870 in the pre-crisis period, respectively.

Panel C provides descriptive data for the post-crisis period, from 2008 to 2015. The data in this panel indicate that the real price of WTI and the median house price in Texas are higher in the post-crisis period when compared to the pre-crisis period. The mean and median real prices of WTI are $44.50 per barrel and $45.64 per barrel, respectively, while the mean and median real house prices are $81,510 and $80,210, respectively. Overall, the descriptive statistics reported in Table 1 indicate that oil price and home prices changed during our sample period. It remains to be seen whether the movement in housing price can be explained by the movements in WTI price.

Figures 1 provides graphical representations of the real WTI price and the real house price in Texas. In Figure 1, the trend shows that the median house price increased from 1990

Figure 1
WTI price and housing price (in $000) in the state of Texas, January 1990 – April 2015.



until 2002-2003, declined until 2011-2012, and increased until reaching the highest price of $102,880 in April 2015. The graph for the WTI price shows a steady increase until June 2008, a sharp fall in 2009, and fluctuations thereafter.

B. Vector Autoregressive Analysis

Augmented Dickey-Fuller (ADF) Test

To examine the impact of oil price changes on house price in Texas, we utilize a vector autoregressive framework which requires both series to be stationary. We employ the following Augmented Dickey-Fuller (ADF) procedure to test if the variables are stationary in levels or in their first difference.

$$\Delta Y_t = \alpha_1 + \alpha_2 Y_{t-1} + \sum_{k=1}^{K} \delta_k \Delta Y_{t-1} + \varepsilon_t \qquad (1)$$

Where, ΔY_t is the first difference operator, α_t and δ_t are constant unknown parameters, and ε_t is zero mean white noise error term. The K-lagged difference terms are chosen so that the error term ε_t becomes white noise. The null hypothesis that Y_t contains a unit root i.e., Y_t is non-stationary, amounts to testing whether $\alpha_2 = 0$. The series is considered stationary if α_2 is negative and significantly different from zero. The distribution for the ADF statistics is given in Fuller (1976). The optimal lag length (7 months) are chosen based on the Akaike Information Criterion (AIC).

The ADF results for the level and first differences are reported in Table 2. For the level, we reject the null hypothesis of non-stationary for both oil and house prices; and for the first difference of the variables, we fail to reject the null for both variables.

Table 2
Results of the ADF tests.

Variables	Level	First Difference
Real WTI Price	–2.17	–9.44
Real Median House Price in Texas	–1.49	–5.03
1% critical value	–3.45	–3.45
5% critical value	–2.87	–2.87
10% critical value	–2.57	–2.57

Variance Decomposition Results

The variance decomposition analysis reports the variance of the forecast errors for house price in Texas due to shocks in the WTI price. The 12-month results shown in Table 3 indicate that, for the entire sample period, a change in the WTI price explains about 4.34 percent variation in the change in the housing price by month 1 and about 8.23 percent by month 12. The variations are more pronounced in the post crisis period. In this period, about 8.43 percent variations of changes in housing price within month 1 can be explained by changes in the WTI price. By month 12, about 11.03 percent variance of the housing price can be explained by the WTI price.

Table 3
Decomposition of variance in median housing price in Texas due to a shock in WTI price.

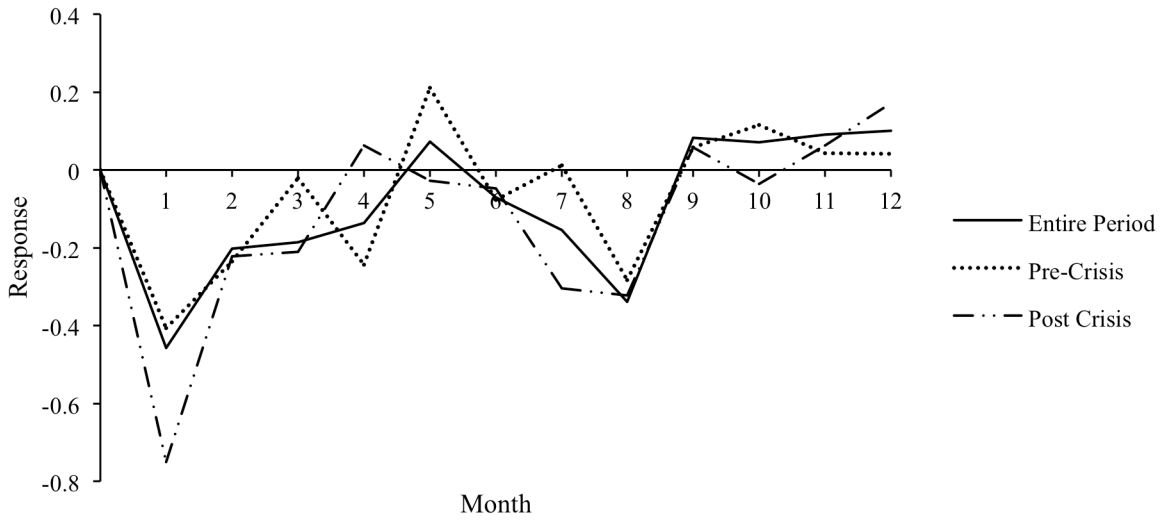
Month	Entire Period (1990-2015)	Pre-Crisis Period (1990-2007)	Post Crisis Period (2008-2015)
1	4.34	4.19	8.43
2	4.81	5.19	8.46
3	5.42	5.09	9.01
4	5.75	6.36	9.06
5	5.78	7.11	9.05
6	5.73	7.13	8.76
7	6.08	7.06	9.83
8	7.85	8.55	10.82
9	7.88	8.55	10.66
10	7.94	8.77	10.66
11	8.07	8.80	10.70
12	8.23	8.83	11.03

Impulse Response Results

We use the impulse response function to trace the effect of a shock to the WTI price on the future housing prices. Figure 3 depicts the responses of the monthly change in home price to a one standard deviation shock in the monthly change in WTI price. The findings indicate that the WTI price shock has a negative initial impact on the housing price during the entire sample period, as well as during the pre- and post-crisis periods. Within month 1, a one standard deviation shock to the WTI price results in about -0.40 percent change in the house prices in Texas. During post crisis, the response is more than -0.70 percent. These results suggest that residents in Texas lower their demand for housing fairly quickly following a positive shock to the oil price. The response is deeper during economic crisis and periods of high oil price. Additionally, the effects of oil price shocks on house prices in Texas last longer and taper toward zero after month 9.

Figure 2

Impulse response of housing price in Texas due to a shock in WTI price



Overall, our findings showing a link between oil price and house price in Texas have decision implications for developers, homebuilders, investors in real estate securities, home buyers and sellers. These stakeholders should closely monitor both short-term and long-term changes in oil price especially during periods of economic crisis. They may consider using an aggressive policy response to changes in oil price because of the immediate impact of house prices to a shock in oil price. The economic policy-makers in the state of Texas and other energy states can mitigate the impact of oil price on the housing market by adjusting economic benefits such as lowering sales and property taxes when oil prices are rising.

V. CONCLUSIONS

Texas is the largest oil producing state in the U.S. and the strength of its economy is fueled by oil and gas activities. It is expected that its housing market, as part of the economy, will be impacted by the movements in oil price. This study examines the relation between oil price and housing price in the state of Texas. Since the economic crisis and a high level of oil price beginning 2008 may have changed the dynamics between these two variables, we perform our empirical analysis for the entire sample period, 1990 – 2015, and for pre-crisis and post-crisis periods.

The variance decomposition analysis shows about 9 percent home price variation due to a shock in the WTI price in the pre-crisis period and about 11 percent home price variation in the post-crisis period. The impulse response results show negative responses following shocks in oil prices, mainly in the post-crisis period. The negative impact of oil price on house prices in the state of Texas indicates a demand effect. As oil price increases, consumers in Texas have less funds available for the housing market, especially during periods of high oil prices.

Some key caveats apply to our findings. First, the impacts on the city housing markets are not addressed in our study. Some of the Texas cities whose economies are dependent on oil and gas may have a deeper impact in their local housing markets as oil price changes. Future studies may examine the impact of oil price changes on the city housing markets. Second, other sectors of the economy in Texas can also be impacted by oil price. For example, retails sales may fall as unemployment increases due to a drop in oil revenue. Future studies can address this research issue. Finally, the housing market in Texas may have a relationship with other oil and gas metrics such as rig counts and workforce in the oil and gas sectors. Analyzing housing markets in relation to these performance metrics can provide better insights.

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THE COMPUTER-BASED CPA EXAM: TEN YEARS IN THE REAR VIEW MIRROR

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ABSTRACT

2014 marked the 10-year anniversary of the introduction of the computerized administration of the CPA exam. This paper analyzes the changes in content and administration of the exam since its inception with emphasis placed primarily on the last 15 years. The paper includes a state by state analysis of exam pass rates, identifying which states saw the greatest improvement and which states saw the least improvement or deterioration in CPA passage rates during this time. For those states identified as the most improved or least improved in regards to exam pass rate, additional analysis is done to evaluate factors such as the average age, gender, level of education, and whether the candidate was actually a resident of the state where he/she took the exam. The paper draws notable conclusions regarding the demographic make-up of the top tier and lowest tier states, when ranked by pass rate. A secondary conclusion is also proffered regarding which category of state (top tier or lowest) is growing the fastest when ranked strictly on the number of exams taken.

Key Words: CPA exam pass rate, CPA exam format, Computer based CPA exam, CPA exam state qualifications, Residency requirements

A Brief History Lesson and Literature Review

Public accounting ranks with medicine and law as one of the most respected professions in society today. This status for Certified Public Accountants [CPAs] largely developed through the recognition of the need for the administration of an examination of accepted professional competency, the Uniform Certified Public Accounting Examination [CPA Exam]. 1917 marked the administration of the first uniform CPA Exam.[Lam,2009] Participants in this exam included "…34 candidates from New Hampshire, Oregon, and Kansas". This first uniform examination tested candidates' competency in the areas of auditing, commercial law, theory and practices. "All the questions were either essay or long problems". (Moore, 2008, p.4) Eligibility for this exam required candidates to have a high school education but the Board of Examiners could waive that requirement. Thus began the 97 year history of the administration of the uniform examination for accounting professionals. As we acknowledge the 100th anniversary of the administration of the Uniform CPA Exam and pass the 10-year mark following the introduction of a computerized examination format, it seems appropriate to briefly visit the exams developmental and outcome history and engage in some analysis of more recent exam results. From the perspective of addition to existing literature, this paper supplements the work of authors who studied CPA pass rates after adoption of the computerized format [e.g. Briggs and He, 2012] and authors who studied it prior. [e.g. Gramling and Rosman, 2009; Grant, Ciccotello, and Dickie, 2002.]

Starting in 1942 and continuing through 1993, the modern version of the CPA exam emerged. This version of the exam offered the following sections: Auditing, Commercial Law, Theory (now separate from Accounting Practice) and two parts on Accounting Practice. The exam also expanded from a two day to a two and one half day format. However, not until 1950 and after, due to the influence of the American Institute of Certified Public Accountants, did most states adopt a college education as a requirement to be eligible to sit for the exam.[Moore, 2011]

Major changes to the exam format came next in 1994. For the first time, candidates could use four-function calculators provided by the examiners during the administration of the exam. Additionally, the format of the exam, once again administered over two days, changed to four parts: Financial Accounting; Tax, Managerial, and Governmental; Auditing; and Business Law. And, for the first time examiners evaluated writing skills as a graded part of the exam.

2004 marked the most recent and most major change in exam format and administration. First, the exam, administered via computer, took place in designated electronic testing sites. Second, the four exam parts, now Financial Accounting [FAR], Regulation [REG], Auditing [AUD], and Business Environment and Concepts [BEC], could be taken individually with exam access being offered eight months out of the year with four specific months designated as blackout periods. Prior to this change the exam administration occurred only twice each year, in May and December, and candidates were required to take all parts of the exam

simultaneously. If retaking part of the exam, all retaken parts were required to be taken simultaneously. Table 1 below summarizes the most recent changes to the exam.[DeFelice, 2010]

In addition to these transitions, starting in 1979, when Florida introduced a requirement that CPA candidates must complete 150 college level academic hours in order to be eligible to sit for the exam, the AICPA urged Uniform CPA Exam jurisdictions to also adopt a "150 hour rule." By 2010, 47 states had adopted this requirement in one form or another. Currently, 32 states considered to be "150 hour" states do not require 150 hours to be eligible to sit for the CPA exam. Generally, the requirement is 120 academic hours to sit for the exam and 150 hours to be eligible for licensure or a permit to practice. [Allen and Woodland, 2006]

Table 1
CPA Exam Attributes Over Time

1942 - 1993		**1994 – 2003**		**2004 – Present**	
Hand Written		Hand Written		Computerized	
Parts Taken Simultaneously		Parts Taken Simultaneously		May Take One Part at a Time	
No Calculating Devices		Simple Calculator Provided		Computer Resources Available	
Exam Part	Time Allowed	Exam Part	Time Allowed	Exam Part	Time Allowed *
Practice	4.5 hr.	FARE	4.5 hr.	BEC	3 hr.
Practice	4.5 Hr.	AUD	4.5 hr.	FAR	4 hr.
Audit	3.5 hr.	ARE	3.5 hr.	REG	3 hr.
Business Law	3.5 hr.	LPR	3 hr.	AUD	4 hr.
Theory	3.5 hr.				
Total	19.5 hr.		16.5 hr.		14 hr.

[NASBA, 2014; Moore, M., 2008; actual exam documents from 1982]
* Allowed times have changed over period. Table reflects current allowed time.

Further, the AICPA is instituting additional changes to the CPA exam without actual format change for exams to be administered in 2017 and following.[Tysiac, K., 2015]

Changes, such as those in the delivery method of the CPA exam, the requirements to sit for the exam, and the actual makeup of the sections of the exam, do not occur without resulting consequences. This paper analyzes one of those consequences: changes in the U.S. CPA exam pass rate, by state for the time period 1999 to 2013. We extracted data regarding CPA exam results from The National Association of State Boards of Accountancy [NASBA], which accumulates and stores multifaceted sets of CPA exam data. The period chosen for

examination in this study encompasses the final five years the exam was administered in a hand written format (1999-2003) and the most recent five year period within which examiners utilized an on-line, computerized exam format (2009-2013). All analysis uses average pass rates for the five year periods as opposed to single year pass rates. This compilation is utilized because considerable volatility arises when analyzing changes in pass rates in single years in single states. The choice of five year periods of analysis allows for the detection of significant trends over time while smoothing out single year positive or negative aberrations.

Within the initial five year period (1999-2003), the Board of Examiners oversaw exam administration twice per year, each May and November. For our research, annual pass rates for a specific exam section were calculated by weighting the May and November pass rates (by state) as well as the number of candidates taking the exam in the administration months. For the next ten years (2004 – 2013), NASBA determined exam section pass rates for all states for each year. A final "All Part" pass rate calculation by state by year for all 15 years encompassed data from both pre-computerization and the computerized periods. This "All Part" metric reflects a calculation of average section pass rate taking into consideration all sections taken. This should not be confused with the pass rate for individuals passing all parts at one sitting. Calculation of this "All Part" rate for each state derives from averaging the four section calculated pass rates for the period 1999-2003 or the provided pass rates for the periods in the 2004-2013 range, for a particular year. During the 15 year study window, the subject matter covered in each part of the exam changed significantly as the composition morphed from the FARE/AUD/ARE/LPR exam to a FAR/AUD/REG/BEC format in 2004 (see Table 1). As a result, no valid, meaningful comparison can be undertaken between a single pre-2004 individual section result versus a post-2003 single section result for any individual section other than for AUD. Because AUD was the only pre-2004 section comparable to a post-2004 section, this paper focuses on analysis of state reported "All Part" pass rates over time.

Change in "All Part" Pass Rate

For the base period paper exam (1999-2003), the individual state "All Part" pass rates in nominal terms, varied from a 15.69% success rate in West Virginia to 46.74% success rate in Utah. For the 2009-2013 period, "All Part" pass rates exceeded the 1999-2003 pass rate in 49 out of 50 states. The 2009-2013 nominal average pass rate varied from 35.90% in Delaware to 60.30% in Utah. When looking at all individuals taking the exam, the "All Part" pass rate increased from 30.75% in the base period to 48.21% in the final five year period. Table 2 below shows the five states with the largest percentage increase in "All Part" pass rates from the initial 1999-2003 period to the 2009-2013 period. Table 3 depicts the five states with the smallest increase (or decrease) in "All Part" pass rates over the same period. For both Tables 2 and 3 9and Appendix A), all percentages should be considered increases in the pass rate, unless depicted as negative a negative number.

Table 2	
"All Part" Pass Rate Most Improved States	
Best Period to Period Outcomes 1999-2003 period to 2009-2013 period	
State	Change in All Parts Pass Rate
South Carolina	30.84%
Kentucky	29.07%
Massachusetts	28.04%
Michigan	26.81%
Missouri	26.75%

Table 3	
"All Part" Pass Rate Least Improved States	
Worst Period to Period Outcomes 1999-2003 period to 2009-2013 period	
State	Change in All Parts Pass Rate
Delaware	-0.73%
Montana	3.16%
New Hampshire	4.47%
New York	7.33%
Maine	9.29%

Clearly, a wide range of improvement (or non-improvement) in pass rates across states occurred between the 1999-2003 period as compared to the 2009-2013 period. Keep in mind that at the starting point of the analysis (1999-2003) the examiners administered a standardized four part exam twice annually wherein candidates were initially required to take all exam parts necessary to pass simultaneously. During the end point of the analysis (2009-2013), the CPA exam testing process allows individuals to sit for single sections of the exam and the exam to be taken at numerous times and places throughout much of the year. Putting aside any changes in the content of the exam, the additional flexibility to sit for a single exam section at a selected date and time (within prescribed windows) and a selected testing center location is generally viewed as creating an advantage for today's candidates. Additionally, changes in a particular state's pass rate from one test period to another, arguably depends upon the pass rate for a given state in the base period (1999-2003); i.e. a state with a 20% pass rate in 1999-2003 may find

it easier to show a percentage improvement compared to a state with a pass rate of 40% in 1999-2003 window.

This paper does not attempt to identify all causes of changes in the CPA pass rate by state and why one state did better than another. Rather, the paper points out notable and observable differences in the make-up of average candidates within states and the requirements imposed on candidates sitting for the exam in the various states (see Table 5). Because only limited demographic data is available for the 1999-2003 period, the analysis here focuses primarily on state demographic data for the 2009-2013 period wherein NASBA provides more data. Table 4 below shows a mini-demographic profile of all candidates in the five most improved states and the five least improved states from 1999-2003 to 2009-2013.

Table 4		
CPA Exam Candidate Demographics		
Candidate Descriptor 2009-2013	States With Largest Increase in CPA Pass Rates (MO, MI, MA, KY, SC)	States With Smallest Increase (or Decrease) in CPA Pass Rates (DE, MT, NH, NY, ME)
Average Age (Years)	27.97	29.34
Percentage Male	49.39%	51.84%
Percentage Advanced Degree	16.28%	10.22%
Percentage Candidates Reported "In-State"	86.41%	50.40%

Several observations arise on examination of Table 4. First, candidates in the states with the greatest improvements, on average, report being slightly younger and marginally more likely to be female. Second, data indicates that candidates in the states with the greatest improvement are more likely to hold advanced degrees by a margin of about 6%. Most notably, by a surprisingly large margin, candidates in the five states with the worst outcomes were more likely to list an out of state address or international address on their exam application.

For general comparative purposes, nationally, 50.08% of reporting candidates indicated their gender as female and 14.29% of the candidates reported holding advanced degrees. 77.09% of all candidates listed in-state addresses with the remainder reporting as either out of state or international. During the 2009-2013 period of study, of all CPA candidates taking the exam in the 50 states, Kansas lead the nation with the largest in-state candidate proportion of 97.02%. New Hampshire, one of the states with the worst period to period performance, reported the lowest in-state percentage of applicants at 5.97%. Table 6 below lists the 2009-2013 in-state candidate rates for the states with the best and worst all part pass rate rankings. With the exception of New York, all of the best performing states reported a far higher proportion of in-state takers than the worst performers. This performance

difference for the "worst" states may indicate a self-selection bias created by weaker candidates selecting examination states by ease of qualification. As shown in Table 5, Delaware and Montana did not require a college degree to sit for the exam and Delaware and Maine did not require any non-accounting business related hours for eligibility to sit; whereas, all best performing states required both an undergraduate degree and additional business hours for eligibility. Specific state by state information follows in the appendix.

Table 5						
CPA Exam Qualification Requirements						
Comparative Data for States with Best Outcomes Period to Period						
State	Degree	Total Hours	Accounting Hours	Business Hours	Residency	Other
South Carolina	UG	120	24	24	NO	
Kentucky	UG	120	27	12	NO	
Massachusetts	UG	120	21	9	NO	
Michigan	UG	120	24	24	NO	
Missouri	UG	150	33	37	YES	
Comparative Data for States with Worst Outcomes Period to Period						
Delaware	Assoc. pre 08/12	Not Specified	21	None	NO	
Montana	Not to sit	Not Specified	24	24	NO	1.
New Hampshire	UG	120	12	24	NO	
New York	UG	120	12	None	NO	
Maine	UG	120	15	None	NO	2.
Assoc. = associates degree UG = undergraduate degree [NASBA, 1999-2013]						

1. Non-supervising CPA can verify experience
2. Changed in 2012 – pre 2012 requirements not available

An attempt was also made to generate a relative analysis of the change in the percentage of total CPA exam candidates who took their exam in either the five best or worst improving state groups over time. For the 1999-2003 period, the number of exam candidates includes those taking the full exam and those who have previously "conditioned" the exam and now taking one or more exam sections in that year. For the 2009-2013 period, the reported number of candidates reflected the number of unique candidates taking one or more sections of the

exam in that given year. A period to period analysis clearly generates an apples to oranges comparison. A more relevant comparison calculates the percent of total applicants each five state group commands over time. Looking at the period 1999-2003, the five greatest improving states tested 9.11% of the total U.S. candidates while the least improving states examined 17.29% of the total U.S. candidates. Although not totally comparable, in the latest period, the five greatest improving states included 7.93% of the total CPA unique candidates given in the U.S. while the least improving states included 17.58% of the total U.S. unique candidates.

Table 6		
Percentage of Exam Applications Considered to be In-State		
State	Best Period to Period Outcomes	State Ranking
South Carolina	76.21%	37
Kentucky	87.37%	27
Massachusetts	84.71%	33
Michigan	91.41%	21
Missouri	87.24%	26
Worst Period to Period Outcomes		
Delaware	7.51%	48
Montana	42.22%	45
New Hampshire	5.97%	50
New York	83.55%	35
Maine	7.08%	49

Conclusion and Suggestions for Additional Study

There has been an overall increase in CPA pass rates since the implementation of the computerized exam in 2004. Forty nine out of fifty states showed an increase in the All Parts pass rate during this period. Prior research has examined the effects of many states adopting a 150 hour requirement, beginning in 1979, for candidates to take the exam or become certified. This paper does not readdress the 150 hour rule change nor does it analyze the change in the exam format, administration method, or content. This paper did find the following. When compared to the states showing the least improvement, exam candidates in states showing the greatest improvement in pass rates since the switch to computerized format were 1) on average 1.37 years younger 2) more likely to be female; 3) more likely to have an advanced degree and 4) noticeably more likely to be considered an in-state candidate in the state they took the exam. Additionally, states showing the greatest improvement in pass rates tended to have more rigorous qualification standards to take the exam than states showing the least improvement. Finally, there has been a relative decrease in exams administered in states with the greatest improvement in pass rates and a relative increase in exams administered in states with the least improvement in pass rates since the computerized exam

was introduced. Taking into consideration all these findings, our results may indicate a self-selection bias created by weaker candidates choosing examination in states with easier qualification standards. While it is true, nearly "all ships may rise with the tide" of a change to a computerized format, other factors still substantially affect pass rates and are worthy of additional study.

State by State Data Most Improved States									
State	Pass Rate Increase/ Decrease	Pass Rank Before	Pass Rank After	Average Age (yrs.)	Female %	Advance Degree %	In-State %	Before % of Total US Exams	After % of Total US Exams
South Carolina	30.84%	42nd	6th	28.29	50.9%	.87%	76.21%	.79%	.65%
Kentucky	29.07%	49th	27th	29.10	50.6%	.68%	87.37%	1.40%	.89%
Massachusetts	28.04%	40th	12th	27.40	51.9%	21.74%	84.71%	2.75%	2.96%
Michigan	26.81%	34th	8th	28.35	47.4%	15.65%	91.41%	2.46%	2.03%
Missouri	26.75%	23rd	2nd	27.76	52.4%	22.82%	87.24%	1.71%	1.39%

State by State Data Least Improved States									
State	Pass Rate Increase/ Decrease	Pass Rank Before	Pass Rank After	Average Age (yrs.)	Female %	Advance Degree %	In-State %	Before % of Total US Exams	After % of Total US Exams
Delaware	(.73%)	10th	50th	33.34	51.6%	8.30%	7.51%	4.05%	1.35%
Montana	3.16%	3rd	37th	28.99	49.8%	2.39%	42.22%	0.22%	0.55%
New Hampshire	4.47%	7th	42nd	30.69	42.8%	12.81%	5.97%	0.90%	3.50%
New York	7.33%	8th	38th	27.76	49.8%	9.92%	83.55%	11.05%	10.02%
Maine	9.29%	17th	43rd	32.06	46.8%	10.65%	7.08%	1.07%	2.16%

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