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Information Systems Education Journal

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AACSB Learning Goals: One-Minute Guest Speakers Help To "Close-the-Loop"

Randy Ryker
randy.ryker@nicholls.edu
Information Systems, Nicholls State University
Thibodaux, LA 70310, USA

Abstract

A key activity in any assurance of learning process is to identify learning deficiencies and then to develop and implement tools and strategies to correct the deficiencies. The activity is often referred to as "closing-the-loop." This paper describes a process whereby the College of Business's Board of Advisors is engaged in a series of short videos. On the videos they talk about the College's learning goals and the importance of the goals to the business community. The inventory of short videos is made available to all faculty who can insert them into their presentation software to help close the loop. The development and use of the videos is described. Additional benefits of the videos that go beyond closing the loop are also discussed.

Keywords: closing the loop, short videos, assurance of learning, learning goals, board of advisors

1. INTRODUCTION

Nearly every information systems program in the United States is required by some accrediting agency to establish learning goals, assess how well their students achieve the learning goals and to address any learning deficiencies. Addressing the deficiencies is a process known as "closing-the-loop." In some cases a university or a regional accrediting agency requires such an assessment process for each major (Pringle & Michel, 2007). In other cases an organization like the Association to Advance Collegiate Schools of Business (AACSB) has an assurance of learning (AOL) standard that applies to all programs within the business college (AACSB Accreditation, 2010).

The focus of this paper is on closing-the-loop in the AACSB AOL process, but the concepts can be readily adapted to work with any assessment plan. The specific five-step process AACSB recommends for AOL includes:

Step 1 – Define learning goals and objectives.
Step 2 – Align curriculum with goals.
Step 3 – Identify instruments and measures.
Step 4 – Collect, analyze and disseminate assessment data.
Step 5 – Use assessment data for continuous Improvement (AACSB International, 2007)

The final step in the process, Step 5, uses assessment data to improve student learning and is known as closing-the-loop (Martell, 2007). This step is summarized in the AACSB standards as follows:

> "Measures of learning have little value in and of themselves. They should make a difference in the operations of the school. Schools should show how (AOL) results impact the life of the school. Such demonstration can include uses to inform and motivate individual students and uses to generate changes in curricula, pedagogy, and teaching and learning materials" (AACSB, 2007).

The most recent AACSB standards do not directly mention the 5 step process. However, in their guidance on how to document AOL they state that a school should:

- Define the learning goals for each degree program—this should include both conceptual and operational definitions.

- Show that students meet all of the learning goals for degree programs. Or, if assessment demonstrates that learning goals are not being met, describe efforts that have been instituted to eliminate the discrepancy (AACSB Accreditation, 2010).

The last part of the guidance dealing with efforts to eliminate the discrepancies is what the Association earlier referred to as closing-the-loop. For many schools, this step is the most challenging and is often where the assessment efforts fail (Gardiner et al., 2009). This step has also been found to be one of the greatest concerns about AOL for business school deans (Martell, 2007).

Given these concerns, increasing attention has been focused on efforts to close-the-loop (Abraham, 2006; Gardiner, Corbitt & Adams, 2009; Martell, 2005; Martell, 2007; Omar, Bhutta & Kalulu, 2009; Pringle & Michel, 2007; Redle & Calderon, 2005; White & McCarthy, 2007). For example, Martell (2007), identified a list of actions that can be used for closing-the-loop: (a) new pedagogical techniques, (b) new or modified courses, (c) closer coordination between courses, (d) major curriculum change, (e) faculty development, (f) increase admission requirements, (g) greater use of out-of-the classroom learning experiences (e.g. internships). More recently others have suggested: (a) remediation, (b) adding prerequisites, (c) increasing or changing specific assignments in existing courses, and (d) providing support structures (e.g. tutoring or help session) to close-the-loop (Gardiner et al., 2009). Pringle and Michel (2007) also reported colleges using: (a) the development of better learning objectives, (b) improvements to the curriculum, (c) closer coordination of multi-section courses and (d) adoption of more effective teaching methods.

This paper describes the development of a new tool and strategy that faculty can use to assist them with closing-the-loop. The new tool is a set of short videos that feature members of the College's Board of Advisors talking about the importance of the College's learning goals. Each video features a board member addressing one of the learning goals and describing how the goal is relevant and important in the context of their particular business. Faculty can embed the videos in their presentation software and use the videos to reinforce their own efforts to emphasize the learning goals. In effect, the set of videos serves as an inventory of one-minute guest speakers who can help the faculty close-the-loop.

Background

Participation of the business community is considered a best practice by the AACSB when defining a College's learning goals (AACSB Accreditation, 2010). External constituencies bring experiences and perspectives that enrich the discussion. Certainly members of the College's Advisory Board should be included in developing the College's learning goals. Other business leaders, including recent graduates of the College, can also offer a useful perspective on the strengths and weaknesses of programs, and when possible, their input should also be considered. This paper describes a way to extend the participation of external constituencies from simply defining learning goals into efforts to close-the-loop.

The historical use of classroom educational films can be traced from the silent era through the 1980's when film began to lose ground to digital media (Alexander, 2010). The body of research on the earlier forms of educational video may be of use to practitioners who utilize newer technologies such as DVDs and YouTube. Although an extensive review of the early literature on the uses of educational videos is beyond the scope of this paper, a comprehensive examination of the topic can be found in a book by Wetzel, Radtke and Stern (2007). In their book they review research on a variety of issues including:

- Teaching techniques used effectively with video media;
- The combining of visual and verbal information;
- The effect of various video production techniques on learning;
- The relationship between media perceptions and learning; and
- Critical perspectives on learning from media (Wetzel et al., 2007).

The use of video to teach business concepts is certainly nothing new. Today numerous videos of national and international business leaders are available to facilitate teaching. The web site of Films for the Humanities and Sciences offers over 6,300 digital educational videos; 1,224 of them are related to business and economics (FFH, 2010). The videos range in length from twenty minutes to an hour or more and address broad national and international business issues.

What's different about the approach described in this paper is the use of much shorter videos, one to two minutes in length, that focus on regional business leaders speaking about specific learning goals of the College, and how the goals are relevant to regional businesses.

2. NEW TOOL AND STRATEGY

Development

In the Fall of 2005, the Advisory Board of the College of Business and the faculty met for a day-long strategic planning retreat. A strategic planning consultant was contracted to facilitate the meeting. Along with a traditional SWOT analysis, the mission of the College was discussed. The establishment of a broad set of learning goals to support the mission was also considered. In the following months, faculty used input from the retreat to establish the College's mission statement and the College's learning goals to support the mission. This approach to setting learning goals is consistent with the best practices recommended by the AACSB (AACSB Accreditation, 2010).

Given the current emphasis on closing the loop, the author suggested a way to engage the College's advisory board members in the process. The approach presented here takes some of the best practices from Step 1 in the AOL process, the setting of learning goals, and applies them to Step 5, closing the loop.

Prior to the May 2008 Advisory Board meeting, each board member was provided a list of the learning goals and was asked for permission to film them discussing the importance and relevance of the goals in their specific businesses. They were also informed that relatively short responses of 1 to 2 minutes were preferred because we planned to allow faculty to embed the videos in classroom presentations. Fifteen of the board members agreed to participate in the filming. As Table 1 shows, not all board members addressed every learning goal.

Eight members addressed the goals of Communications and Ethics; seven members addressed Critical Thinking and Disciplinary Knowledge; six discussed Diversity and Multiculturalism and five Collaboration. The responses ranged in time from a minimum of 6 seconds to a maximum of 1 minute and 45 seconds, with an average time of about 30 seconds. The size of the files ranged from 2KB to 33KB when saved in a MPG format compatible with PowerPoint.

Communications
- N = 8
- Max = 33KB; 105 seconds
- Min = 8KB; 24 seconds

Collaboration
- N = 5
- Max = 32KB; 96 seconds
- Min = 9KB; 27 seconds

Critical Thinking
- N = 7
- Max = 28KB; 84 seconds
- Min = 6KB; 18 seconds

Disciplinary Knowledge
- N = 7
- Max = 22KB; 66 seconds
- Min = 6KB; 18 seconds

Diversity and Multiculurism
- N = 6
- Max = 29KB; 87 seconds
- Min = 5KB; 15 seconds

Ethics
- N = 8
- Max = 26KB; 78 seconds
- Min = 2KB; 6 seconds

Table 1. Learning Goal Videos

The videos were filmed while board members were sitting around a conference table in a room designed for the Executive MBA program. None of the responses were scripted. Each board member was given an opportunity to speak about the importance of any of the learning goals they chose to respond to. There were no "re-takes" and only basic editing was required to split the responses into individual files for use in PowerPoint.

A local media company volunteered to record, edit and produce the videos at no charge to the College. The results were delivered on a DVD approximately two months after the filming. The faculty was made aware of the inventory of video clips at a College-wide faculty meeting in the Fall 2008.

Use of the Videos

The full extent of use of the videos has not yet been assessed. One minor complication of the project was that the files were delivered in VOB format, and the presentation software, PowerPoint, did not support that file type.

Before the faculty could insert the videos, they had to be converted to a compatible format. The computer services group at the University agreed to do the conversion at no cost to the College. A second minor problem was that some faculty did not know how to add a video file to a PowerPoint presentation. One faculty member researched the issue and produced a one-page handout that described the process. This ancillary activity may be seen as faculty development.

The author has used these clips and has found that students respond well to them. It is helpful to have these one-minute guest speakers on video to reinforce key points about learning goals. Additional promotional effort would help to get more of the faculty involved in using the videos. If the AOL process identifies gaps in students' knowledge of the College's learning goals, faculty must find ways to address the deficiencies. One way faculty members typically address the deficiencies is to either emphasize related material from their current lectures or present new material related to the learning goals. Whichever approach they take, their materials can be reinforced by using the short videos described in this paper.

Additional Benefits

The tool described in this paper was developed proactively and not in response to any gaps in knowledge that had been identified by the AOL process. It was expected that a gap in knowledge of one or more of the college's learning goals would be identified at some point during the assessment process, and that these videos could be used to help address the gap and thereby help to close-the-loop. One may argue that such proactive effort is wasted in the event that no learning gaps are identified. However, in addition to providing the faculty with a new tool and strategy to close-the-loop, other benefits, some beyond student learning, can be identified:

- By asking the Advisory Board members to participate in the videos, we raised awareness in the business community of what the College is trying to achieve, and engaged them as partners in our educational efforts. Participating board members appeared to appreciate being asked to be involved.
- The videos also served to introduce students to business leaders in the local community. Prior to the use of the videos, many of the students had never met local leaders and had never seen them talk about business issues.
- Similarly, the videos can be used in the orientation of new faculty, to familiarize them with the Advisory Board and local business leaders.
- From the students' perspective, the videos provide an opportunity to break up the lectures with one-minute segments that reinforce points made by the professor. Students become very accustomed to hearing the professors lecture and may at times tune them out. Having a "one-minute guest speaker" can be interesting and helps to focus the students' attention.
- If a local media company or the University volunteers to produce the videos, the cost to the College is minimal.
- The videos are designed to address the College's learning goals and thus should have a relatively long shelf life.
- The approach may be seen by students, the faculty, the advisory board, and the AACSB as an innovation with multiple benefits

3. CONCLUSIONS

The definition of learning goals is Step 1 in the AOL process, and it answers the question, "Assurance of learning what?" Best practices associated with Step 1 include engaging external constituencies, including the Board of Advisors, in setting the learning goals. This paper describes a process whereby these same external constituencies are also engaged in Step 5 of the AOL process, closing-the-loop.

The learning goals addressed in this paper were developed at the college level. One natural extension of this process would be to develop videos at the program level or the major level. The AACSB requires program-level learning goals that address the broad educational expectations for each degree program (AACSB Accreditation, 2010). Faculty at universities with a regional accrediting agency may similarly be interested in using short videos to address AOL issues for each major. The variety of benefits identified in this paper should also apply when individual programs or majors engage their advisory board members in the same process.

Although the project described in this paper was well received by the members of the Board of

Advisors and students; additional research into the use of short videos of regional business leaders to reinforce classroom lectures needs to be conducted. For example, how effective are the videos in engaging the students in the learning goal topics? Do the students report being more interested in the topics after exposure to the short videos? What is the quality of the follow-up discussion after watching the videos? Are the short videos of regional leaders more effective than the use of longer videos of national business leaders speaking about the same or similar topics? Would the involvement of students in the process of shooting a YouTube version of the videos be even more engaging to the students?

If such videos prove to provide significant improvements in learning then producing and using them should become a best practice. However, regardless of the outcome of such research, given the additional benefits that accrue from the approach, engaging local business leaders in this way seems to be a win-win situation for all involved.

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Using Undergraduate Information Systems Student Epistemic Belief Data in Course Design: A Research-based Approach to Improve Student Academic Success

Samuel S. Conn
samuel.conn@kysu.edu

John English
john.english@kysu.edu

Fred Scheffler
fred.scheffler@kysu.edu

Kentucky State University
Frankfort, KY 40601 USA

Simin Hall
simin.hall@vt.edu
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061 USA

Abstract

In this report the authors detail a baseline study involving use of epistemic belief data to enhance academic success collected from an undergraduate student population enrolled in an Information Systems undergraduate degree program. Based on an existing line of inquiry, student epistemic belief data were collected and analyzed to determine student perception of knowledge and levels of self-regulation and self-efficacy. Indicators were determined through item analysis and evaluated for use with an existing epistemic belief profile rubric. Working in concert with course developers, strategies for altering approaches in instructional design, pedagogy, and assessment based on student epistemic beliefs were determined. Researchers from institutions of similar composition can benefit from findings of this study. Moreover, strategies for altering a student population's trajectory toward improved academic success were an outcome of this study and included application and analysis of: (a) student epistemic belief data and its role in higher education, (b) relationships between epistemic beliefs and student academic success, and (c) a methodology for improving student academic success via research-based instructional design, pedagogy, and assessment.

Keywords: Epistemic, beliefs, academic, success, course design, strategy

1. PROBLEM STATEMENT

The problem examined in this study involved use of epistemic beliefs in course design. Student epistemic beliefs, juxtaposed against the theory of knowledge, degrees of student self-regulation, and cognitive development theories, can be used to design more efficacious courses if an integrative methodology is applied. Creation of a course development methodology involving use of student epistemic beliefs is problematic. Relating theory of knowledge, degrees of self-regulation and self-efficacy, and cognitive development theory as dimensions to construct a student population profile and use of student epistemic belief data to position a given student population within the construct is complex.

In this investigation, the authors illustrated the congruence of theory of knowledge, degrees of student self-regulation, and a cognitive development theory as a framework for determining appropriate course instructional design strategies. A rubric involving student epistemic belief profiles was applied in response to a prescriptive-diagnostic approach (Schunk, 1983). Through this research and case-based study the authors wanted to know: a) what are students' epistemic beliefs regarding knowledge; b) what are students' epistemic beliefs regarding self-efficacy; c) what are students' epistemic beliefs regarding self-regulation; and d) what are students' epistemic beliefs regarding instruction? Once determined, the researchers constructed a profile for the student population based on epistemic belief data.

The profile was used to establish a baseline for pedagogy and assessment strategies; using an existing rubric, a strategy for trajectory to higher levels of epistemic belief was plotted. The authors posit that course designers and developers can apply the design elements to achieve a course of instruction in harmony with an existing student population's epistemic beliefs, or to construct a pathway to alter epistemic beliefs toward an optimal goal of constructivism, commitment and constructed knowledge, and high levels of self-regulation

2. LITERATURE REVIEW

Philosophy addresses the nature and rationale for human knowledge through an area of concern referred to as epistemology. According to Hofer and Pintrich (1997), individual epistemology, or epistemic beliefs, involves one's beliefs regarding the nature of knowledge and knowing. Early theorists (e.g., Perry, 1970; Pintrich and Schunk, 2002; Schoenfeld, 1985; and Hofer and Pintrich, 2002) promoted the idea that epistemic beliefs alter students' learning strategies, problem solving capabilities, comprehension, and achievement of learning outcomes. Major theories developed by educational psychologists such as Buehl, Alexander, and Murphy (2002), Hofer and Pintrich (1997), Muis, Bendixen, and Haerle (2006), Piaget (1950), and Schommer (1990) incorporate and apply some element of student epistemic beliefs.

As a result, epistemic beliefs are deemed to influence learning, motivation, and cognition. Integrative studies of student epistemic beliefs with other learning theories and models have evolved over the past few decades, e.g., Bloom, Engelhart, Furst, Hill, & Krathwohl (1956); Ryan(1984a, 1984b); and Muis (2007).

Based on Hofer and Pintrich (1997), epistemic beliefs affect four dimensions of knowledge: (a) certainty of knowledge, (b) simplicity of knowledge, (c) justification for knowing, and (d) source of knowledge. According to Schommer (1990), certainty of knowledge is reflected as a continuum with a belief that knowledge is absolute and unchangeable on one end as opposed to a belief that knowledge is tentative and evolving on the other end. Moreover, simplicity of knowledge is illustrated as a continuum with a belief on one end that knowledge is defined as isolated, unambiguous chunks as opposed to a belief that knowledge is defined as highly interrelated conceptualizations.

According to King and Kitchener (1994), justification for knowledge also can be depicted as a range where knowledge requires no justification to where knowledge is constructed and critically refined and reevaluated. Based on Kuhn (1993), epistemic beliefs influenced by "source of knowledge" can range from total reliance on and acceptance of authoritative experts, to critical evaluation of expert knowledge.

In accordance with Muis (2007), two high-level architectures exist with respect to epistemic beliefs, one motivated by a developmental perspective and one motivated by a multidimensional perspective. Perry's (1970) work illustrates a developmental perspective in defining a student's initial view of knowledge (absolutism/objectivism), a progression to a more advanced view of knowledge (multiplism/subjectivism), and progressively the highest view of knowledge (evaluativism/objectivism-subjectivism). In contrast, Hammer and Elby (2002), Hofer and Pintrich (1997), and Schommer (1990) proposed multidimensional frameworks, where incremental, non-sequential knowledge dimensions assemble to form and represent knowledge.

Muis (2007) established a relationship between epistemic beliefs, self-efficacy, and self-regulated learning. Investigations, e.g., Ryan (1984b); Schoenfeld (1983, 1985); Schommer (1990); and Hofer (2000), have determined a relationship between epistemic beliefs and levels of meta-cognition. According to Knight and Mattick (2006), researchers increasingly are finding a relationship between epistemic beliefs and disciplinary domains, i.e., epistemological beliefs are discipline specific. In effect, student epistemic beliefs can be juxtaposed with known theories and models of learning to establish baselines for given populations defined by discipline or content domain.

Pintrich and Schunk (2002) demonstrated that successful self-regulated learners possess higher levels of motivation (personal influences), apply more effective learning strategies (behavioral influences) and respond more appropriately to situational demands (environmental influences). In addition, Hofer and Pintrich (1997) hypothesized that epistemic beliefs affect achievement mediated through self-regulated learning.

Schunk (1995) defined self-regulated learning as "learning that results from students' self-generated thoughts and behaviors that are systematically oriented toward the attainment of their learning goals" (p. 125). Moreover, Bandura (1986) showed that self-efficacy beliefs impact performance because these beliefs represent people's perception of their capabilities to perform a task at designated levels. These researchers have provided empirical data on causal or correlation relationships between self-efficacy and epistemic beliefs and self-regulated behaviors and performance in subjects such as mathematics (Pajares & Miller, 1994; Schommer et al, 1992; and Schunk, 1981, 1984).

Social constructivism (Pajares, 2002) provided a basis for this case study's course construction recommendations and related instructional strategies. Social constructivism suggests that the exchange of critical feedback among peers as well as from the instructor can encourage students to modify their work. Learners engaged in a collaborative problem solving process receive feedback and comments from peers and from the teacher on related steps of planning, implementing, and executing problem solving processes rather than only receiving feedback from the instructor on their performance.

Feedback is an important consideration because it requires transfer of knowledge and therefore represents students' gain in problem solving (Clark & Mayer, 2003). In particular, feedback from peers may push students to perform higher level cognitive functions (Schoenfeld, 1983). Furthermore, social cognitive theory posits reciprocal interactions between behaviors, cognitions, and environmental variables (Bandura, 1984) can enhance self-efficacy as it relates to problem solving skills. Feedback from peers and instructor are environmental variables as well as the modes of course delivery that can influence student confidence as it relates to the acquisition of problem solving skills (Schunk & Pajares, 2002).

Moreover, social cognitive theories posit as possible the design of an educational experience such that learning occurs and is enhanced as a result (Marra & Palmer, 2004). Designing a course such that student learning takes place requires examining student epistemic beliefs, how feedback is utilized during learning, as well as student perceptions of teaching and learning. For example, students who require and expect more instruction do so in part because of their epistemic beliefs regarding the nature of knowledge and knowing. Research has shown that epistemic beliefs affect how students approach learning tasks (Schoenfeld, 1983), monitor comprehension (Schommer et al., 1992), and plan for solving problems and carry out those plans (Schommer, 1990).

Course design can be used to enhance collaboration and feedback through active engagement with materials and collaboration with peers and instructors. Online resources such as chat, discussion forum, blog, and wiki can play an active role in facilitating collaboration and feedback. One appeal of asynchronous technologies is that learners can access materials, complete assignments, participate in discussions, and take exams according to schedules that they themselves determine. Hypermedia learning environments offer particular advantages to learners who are inherently self-directed learners (Mayer, 2002).

However, at many institutions the current population taking courses consists of traditional undergraduates. These students typically require and expect more structure and instruction (Ravert & Evans, 2007). Many students, particularly those with low motivation, achievement, and self-regulation are unwilling to do mindful work, such as executing higher level cognitive processes that are involved in scholastic work (Report to Congress, 2004).

3. METHODOLOGY

Researchers in this study utilized a mixed-method approach in collection of qualitative and quantitative data (Creswell & Clark, 2007). A case study methodology was used to collect relevant qualitative data regarding the subjects of the study, undergraduate students in their first year of study. Likert scale data were collected; survey instrumentation was used to collect quantitative data involving dimensions of student epistemic beliefs. Based on an item mean analysis of the quantitative data, the student population was identified by level of epistemic belief: simple, moderate, sophisticated.

Moreover, data analysis included standard Pearson Correlation Co-efficient (*r*) and Factor Pattern analysis using Eigenvectors and Varimax rotation method. In accordance with existing lines of research regarding epistemic belief data, the researchers determined the most efficacious framework for instructional design, pedagogy, and assessment to improve student success in Information Systems coursework.

In this mixed-method investigation a qualitative case study methodology was applied and supported by quantitative data from an undergraduate Information System student population. The diagnostic- prescriptive framework involved a logic chain beginning with collection of data from a specific population regarding student epistemic beliefs. Data analysis and conventional heuristics yielded prescriptive indicators of placement of the sample student population relative to a three-dimensional framework (Figure 1) constructed in concert with accepted learning theories and models (i.e., developmental perspective models and multidimensional perspective models) and the social cognitive theory of self-regulated learning.

Based on the three-dimensional framework, a rubric of 27 design elements for course construction was applied. Course design elements in the rubric accommodate Bloom's hierarchy of cognitive development, synchronous and asynchronous pedagogical strategies, and assessment of learning achievement based on level of epistemic belief (Hannafin & Hill, 2007).

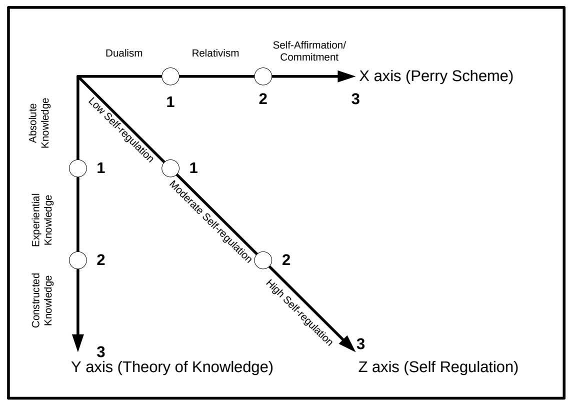

Figure 1: Framework for determination of learner epistemic beliefs profile
Source: Conn, Hall, and Herndon (2010)

As illustrated in Figure 1, three axes representing continuums based on Perry's scheme, theory of knowledge, and levels of self-regulation were abstracted as a cube with 27 distinct co-ordinate dimensions: x1, y1, z1 through x3, y3, z3. This three-dimensional modeling technique was used to identify specific characteristics and profiles for a given population of learners. To create the x-axis (Figure 1), Conn, Hall, and Herndon (2010) grouped Perry's (1970) nine "positions" relative to knowledge and learning into three groups: dualism, relativism, and self-affirmation/commitment. Dualism includes Perry's positions of basic dualism, pre-legitimate multiplicity, and legitimate but subordinate multiplicity (Marra, Palmer, & Litzinger, 2000). Relativism includes full or legitimate multiplicity, contextual relativism, and foreseen commitment; self-affirmation and commitment includes commitment within relativism.

Based on items means from the data collected, the sample learner population was described based on the three-dimensions. For example, a sample population located in the x1, y1, z1 dimension (Figure 2) would characteristically be described by tendencies toward dualistic knowledge and learning, absolute knowledge, and low levels of self-regulation. This non-optimal position would indicate epistemic beliefs of the lowest order (simple), thus requiring instructional design and pedagogy consistent with initial levels of cognition, student motivation, and self-efficacy (Schunk & Pajares, 2005). Any shift in the dimensional positioning would indicate movement in a positive direction, where mutual recursion or other reciprocal relationship may be evident.

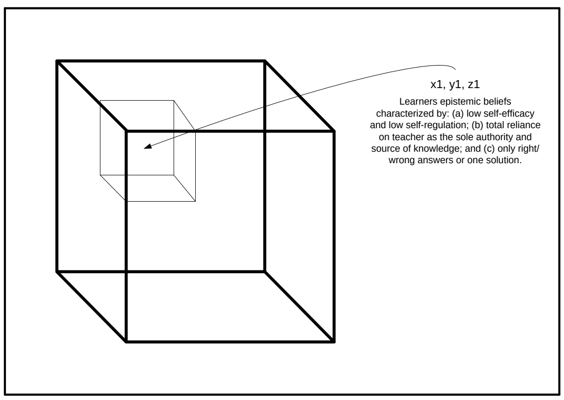

Figure 2: Framework positioning for non-optimal learner epistemic beliefs profile
Source: Conn, Hall, and Herndon (2010)

In another example (Figure 3), a sample population located in the x3, y3, z3 dimension would characteristically be described by tendencies toward self-affirmation/commitment, high levels of meta-cognition, an ability to construct knowledge through collaboration, synthesis, and evaluation, and a high level of self-regulation. This optimal position would indicate highly evolved epistemic beliefs (sophisticated) that could accommodate instructional design and pedagogy consistent with advanced cognition and self-efficacy (Pajares & Kranzler, 1995).

With respect to phenomena involving reciprocity between axes in the framework, a learner population with a cognitive ability to construct new knowledge and act as a source of knowledge would demonstrate higher levels of self-regulation. Conversely, learner populations with higher levels of self-regulation would possess attitudes and epistemic beliefs to construct knowledge, use interdisciplinary approaches in problem solving, and appreciate and incorporate multiple perspectives in the creation of new knowledge.

4. ANALYSIS OF SURVEY DATA

An existing survey instrument was utilized to measure three dimensions: a) students' perception of knowledge and knowing, b) students' level of self-regulation, and c) students' perception of self-efficacy. Thirteen questions measured students' perception of knowledge and knowing, including perceptions of instruction. Eight survey questions related to level of self-regulation. Item responses for these dimensions were obtained using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Fifteen survey questions related to self-efficacy and asked participants how confident they were in solving various problems and their self-confidence as it related to stating what is known or what is to be determined after reading a sample problem statement.

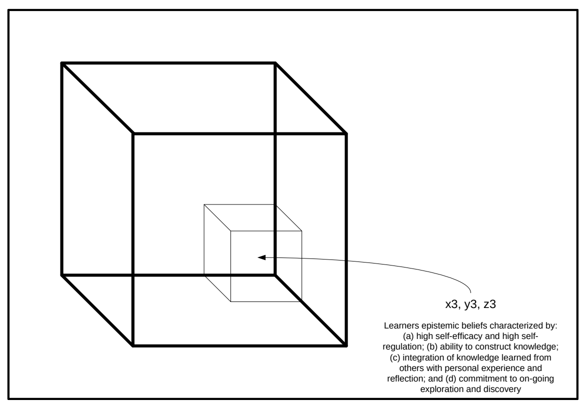

Figure 3: Framework positioning for optimal learner epistemic beliefs
Source: Conn, Hall, and Herndon (2010)

Response options involved a five-point Likert scale ranging from 1 (no self-confidence) to 5 (a high level of self-confidence). The instrument scored a reliability coefficient of 0.86 in this baseline study. Mean scores were computed for each item on the survey. Factor analysis was used to develop three scales for the tree constructs measured in the survey. Chronbach alpha scores were used to ensure reliability for the three scales.

In this study, the sample population (N=28) consisted of undergraduate Information Systems students composed of 14% freshmen, 21% sophomore, 36% juniors, and 29% seniors. Respondents were 21% female and 79% male.

Analysis of Perry's Scheme Sub-scale Data
For item one, students responding with a 4 or 5 (75%) indicated that they agreed or strongly agreed that "A good college instructor often brings up questions that have more than one answer." Therefore, as believed by the student, good (i.e., effective) instruction promotes multiple answers to questions. As a result, a moderate item mean score (3.85 with SD=.854) indicates a preference for instruction originating from multiple sources. The second item, as an indication of tendency, where a response of 4 or 5 (96%) indicated they agreed or strongly agreed that "College instructors should present various ideas on an issue", calculated to a mean of 4.42 with SD=1.09. The students were not skeptical of multiple answers to a single question, thus their tendency is toward hearing all arguments and ideas surrounding an issue. Item three confirms this conclusion where students responding with a 4 or 5 (39%) indicated that they agreed or strongly agreed that "It's not necessary for the instructor to answer all of my questions I ask in class; fellow students can often do it instead" and calculated to a mean of 3.07 with SD=.324.

Further confirmation is seen in item five where students responding with a 4 or 5 (86%) agreed or strongly agreed that "In a good course I would learn as much from fellow students as I would from the instructor" and calculated to a mean of 4.00 with SD=.400. Item seven scored consistently with a mean of 2.67 (SD=.434) when the sample population responded to the statement "In class, I want other students to answer the questions I ask instead of the instructor answering my question." Of students responding with a 4 or 5 (25%), 50% disagreed or strongly disagreed with answers coming from an alternative, convenient source of knowledge (i.e., classmates), indicating emergence to constructivism and away from absolute knowledge.

In concert with movement away from absolute knowledge tendencies, the percentage of students who agreed or strongly agreed with "I like it when an instructor brings up a question that he or she doesn't know the answer to" evaluated to 40%, indicating a transition away from the belief that instructors are authority figures who should know all the answers.

Table 1: Perry's Scheme Sub-scale (x axis)

	Mean	STDEV
Q1. A good college instructor often brings up questions that have more than one correct answer.	3.85	.854
Q2. College instructors should present various ideas on an issue.	4.42	1.09
Q3. It's not necessary for the instructor to answer all of my questions I ask in class; fellow students can often do it instead.	3.07	.324
Q4. I like it when an instructor brings up a question that he or she doesn't know the answer to.	3.07	.400
Q5. In a good course I would learn as much from fellow students as I would from the instructor.	4.00	.969
Q6. I usually like it when my instructor answers a question with "it depends" and follows this statement with a discussion of the topic.	3.82	.666
Q7. In class, I want other students to answer the questions I ask instead of the instructor answering my question.	2.67	.434

For item six, 68% of respondents agreed or strongly agreed that they "usually like it when my instructor answers a question with 'it depends' and follow this statement with a discussion of the topic"; calculated as a mean of 3.82 (SD=.666). As a result, the population generally accepts that knowledge is contextual, indicating relativistic thinking.

In sum, the scores reflected from student responses in the Perry's Scheme Sub-scale (x axis) indicate an evolving preference away from the instructor as an authoritative singular source of knowledge, and outlier tendencies toward multiplicity of knowledge and knowing. The overall item mean for this Sub-scale calculated to be 3.56 (SD=.694) indicating the population holds relativistic beliefs with emerging self-affirmation and commitment tendencies.

Analysis of Absolute Knowledge Sub-scale Data

For item eight, students responding with a 4 or 5 (35%) indicated that they agreed or strongly agreed that "If I heard an instructor say 'we don't know the answer to that', they would worry about taking a class from him/her." As believed by the students, the instructor should not know all, and 39% indicated every question has one correct answer. Moreover, the items together indicate a tolerance for knowledge that is transient or evolving. As a result, a moderate item mean score (2.82 with SD=.464) indicates movement away from a preference for absolute knowledge and knowing.

However item nine, where students responding with a 4 or 5 (14%) indicated that they agreed or strongly agreed that "An instructor who says 'nobody really knows the answer to that' is probably a bad instructor", illustrates a tendency toward evolving and transient knowledge. Combined, item analysis indicates students do not worry if questions have no single answer, and have an emerging acceptance that knowledge does not have to be absolute, dualistic, and unambiguous.

Responses to Item 10 indicate a moderate level of perception of knowledge (item mean of 3.03 with SD=.473) and evolving relativistic tendencies. Of students responding with a 4 or 5 (39%) stated that they agreed or strongly agreed that "There is one right answer for most questions and a good instructor knows it." Nearly half (43%) of the population disagreed or strongly disagreed, indicating strong movement toward experiential knowledge as a basis for learning. This conclusion is supported by item 11 where 32% of respondents agreed or strongly agreed that "A good instructor gives facts and leaves theories out of the discussion." The mean for this item calculated to be 3.17 with SD=.716.

Moreover, item 12 scores lag support and indicate a strong tendency toward absolute knowledge and low self-regulation. Those responding who indicated a 4 or 5 (82%), agreed or strongly agreed with the statement "An instructor's main job is to make sure I learn the course material"; however, the population generally indicates a preference for experiential knowledge that is evolving and transient in nature.

Table 2: Absolute Knowledge Sub-scale (y axis)

	Mean	STDEV
Q8. If I heard an instructor say "we don't know the answer to that" I would worry about taking a class from him/her.	2.82	.464
Q9. An instructor who says "nobody really knows the answer to that" is probably a bad instructor.	3.39	.696
Q10. There is one right answer for most questions and a good instructor knows it.	3.03	.473
Q11. A good instructor gives facts and leaves theories out of the discussion.	3.17	.716
Q12. An instructor's main job is to make sure I learn the course material.	2.07	.440

Analysis of Self-regulation Sub-scale Data

For item 13, students responding with a 4 or 5 (50%) indicated that they agreed or strongly agreed that "It is my own fault if I don't learn the material in a course." As believed by the sample, half take responsibility for their own learning. As a result, a higher item mean score (3.42 with SD=.448) indicates a preference for experiential knowledge and internal motivation to learn. This conclusion is supported in responses to item 14 where students responding with a 4 or 5 (11%) indicate a decrease in accepting a relationship between level of effort and time-on-task and achievement of learning outcomes. A lower mean (2.39 with SD=.398) indicates lower levels of self-regulation in the population. Avoidance of increased level of effort and time-on-task is generally indicated as a contributing factor to low levels of self-regulation. For this sample, 29% agreed or strongly agreed in item 15 with the statement "Often when I am bored, I like to study"; a mean calculation for this item was determined to be 2.60 with SD=.330.

With respect to focus and attention as indicators of level of self-regulation, 25% of the sample agreed or strongly agreed in item 16 with the statement "During the time I am in class, I often miss important points because I am thinking of other things". Mean response to item 16 calculated as 2.53 with SD= .539. In concert with this response, 33% of the sample agreed or strongly agreed that "I often feel so lazy or bored when I study that I quit before I finish what I planned to do". Item 17 mean calculated to 2.64 with SD=.595. Moreover, ability to stay focused also supported low to moderate levels of self-regulation as 36% of the sample (a mean of 2.78 with SD=.480) indicated agreement or strong agreement in item 18 that "I often find that I have been reading for class but don't know what it was all about". Student response to item 19 indicated that 46% agreed or strongly agreed with the statement "I find it hard to stick to a study schedule"; item mean calculated as 3.10 with SD=.473.

These scores support the conclusion that the sample population demonstrates low to moderate levels of self-regulation. Item 20, the final item in the self-regulation sub-scale, evaluated in support of low self-regulation and absolute knowledge as 43% of students (a mean of 3.07 with SD=.406) surveyed agreed or strongly agreed with the statement "In most cases, I can learn the course material whether the instructor teaches it well or not".

Based on the literature, the authors posit that students with overall higher levels of epistemic belief exhibit more self-regulated behaviors, have less preference for absolute knowledge, are able to evaluate multiple views and approaches toward solving problems and learning theories, do not depend on instructors as a singular source for learning, do not think instructors are authority figures and are the only source of knowledge, and enjoy and willingly contribute to peer discussions and collaborative learning.

Table 3: Self-regulation Sub-scale (z axis)

	Mean	STDEV
Q13. It is my own fault if I don't learn the material in a course.	3.42	.448
Q14. If I don't understand the course material, it is because I didn't try hard enough.	2.39	.398
Q15. Often when I am bored, I like to study.	2.60	.330
Q16. During the time I am in class, I often miss important points because I am thinking of other things.	2.53	.539
Q17. I often feel so lazy or bored when I study that I quit before I finish what I planned to do.	2.64	.595
Q18. I often find that I have been reading for class but don't know what it was all about.	2.78	.480
Q19. I find it hard to stick to a study schedule.	3.10	.473
Q20. In most cases, I can learn the course material whether the instructor teaches it well or not.	3.07	.406

A different set of interventions, course design elements, and instructional strategies would be indicated: (a) if students believed knowledge consists of isolated facts and they did not engage in transfer or considered relationships among facts, (b) if students view instructors as the only possessor of knowledge, and/or (c) if students were not prepared developmentally to engage in peer collaboration to solve problems and create knowledge.

Student survey data, organized in Tables 1-3, were related to Figure 1, a framework to profile learner epistemic beliefs, via item means. Indicators for the framework x-axis, a range from dualism to self-affirmation and commitment, are seen in Table 1. Further, indicators for the framework y-axis, a range from absolute knowledge to constructivism, are seen in Table 2. Finally, indicators for the framework z-axis, a range from low self-regulation to high self-regulation, are seen in Table 3. Following a means procedure, item means for each table were calculated (Table 4). The item means were projected into three linear ranges that reflect one of three axes positions in the framework: 1, 2, or 3; defined as follows:

Item Means	→	Axis Position
0.00 - 1.67		1
1.68 - 3.34		2
3.35 – 5.00		3

Prescription for this Information Systems student population was achieved by scoring each variable item mean to an axis position according to the (relative) indicators defined in the framework. Based on the item means for each variable (Table 4) and the item means to axes positioning, this case study population of students was defined within the framework as x3, y2, z2. The mean positioning of x3 indicates the learner population is characterized by relativistic tendencies emerging toward self-affirmation/commitment.

According to Perry (1970), this learner population has moved past views that answers are either right or wrong and problems have only one solution, and have begun to adopt a view that knowledge is contextual and transient. The learner in this population is beginning to accept himself/herself as a legitimate source of knowledge and generally does not consider the teacher to be the absolute authority or source of knowledge.

Positioning of the learner population as y2 comes as a result of variable means of 2.78 from Table 4. In this position the learner is characterized as still having some preference for dualistic, binary thinking, but is fully capable of relativism. To advance trajectory, pedagogy and assessment should involve reflecting on previous experience, collaboration with peers, creation of mental models, and application of cognitive schema; learners in this coordinate position can begin to learn how to construct new knowledge if given appropriate tools and directions. Learners in the y2 position also exhibit a predisposition toward experiential learning, can manipulate a body of knowledge to abstract salient points, and can visualize simple abstract concepts and models. Moreover, learners in this position can incorporate nascent experiences into an existing cognitive framework or reference and accommodate new theories, concepts, and schema (Perry, 1981). Learners at this higher cognitive level also are transitioning from passive to active learners and generally learn by doing.

Table 4: The MEANS Procedure

	N	Mean	STDEV
Table 1: Perry's Scheme Sub-scale (x axis)	28	3.56	.694
Table 2: Absolute Knowledge Sub-scale (y axis)	28	2.78	.633
Table 3: Self-regulation Sub-scale (z axis)	28	2.81	.519

The third axis position, z2, indicates that the learner population experiences low to moderate self-regulation. Learners in this population are guided by moderate cognitive learning strategies, capable of learning in blended or hybrid approaches to instruction, and increasing levels of motivation to learn. To positively alter trajectory, increased meta-cognitive instructional strategies provide learners with a proven path or plan for how to learn, based on prior learning accomplishments. The z2 learner population can develop a diminished need for faculty in the learning process, demonstrate increased persistence toward difficult problems, and alter learning strategies in response to levels of success in meeting learning goals and objectives. This learner population also is characterized by increased self-awareness, higher levels of self-efficacy, and some ability to monitor, evaluate, and alter individual performance, initiative, time-on-task, and level of effort.

The student population is now defined such that design elements can be applied in the construct of a course to more fully engage and accommodate the learner population, or to develop a strategy to alter the trajectory of the learner population toward the optimal position of x3, y3, z3. Once the coordinate position of the learner population is determined, design elements (Tables 5, 6, and 7) with respect to student profile, pedagogical strategies, and assessment mechanisms can be applied via instructional design.

Essentially, mapping this student population position within the epistemic beliefs framework (Figure 1) to course design elements (Tables 5, 6, and 7) provides guidance for course design that most efficaciously meets the needs of the learner population. Moreover, as noted previously, the methodology can be used to establish a trajectory of design to move a given learner population from its defined position to a more optimal position within the framework.

6. APPLYING RUBRICS IN INSTRUCTIONAL DESIGN

The subject of this case study, a population (N=28) of first-year undergraduate students involved in a state university Information Systems program, was evaluated through survey item mean analysis to a coordinate position of x3, y2, z2 with respect to the framework for determination of learner epistemic beliefs profile (Figure 1). Applying the rubric to first identify the student population's epistemic belief profile (Table 5) suggests the class has emerged from dualistic to relativistic and self-affirmed tendencies, is capable of contextual and integrative problem solving, can appreciate multiple world views, and possesses a capacity for critical analysis.

Moreover, the student population has emerging tendencies toward intrinsic motivation, has developed and somewhat embraced a tolerance for ambiguity, and has an emerging sense of the contextual nature of knowledge. Also, the student population most appreciates knowledge based on practical applications. Data analysis also indicates the student population evaluates at a low to moderate level of self-regulation, shows tendencies toward active learning, can differentiate between faculty dependent and student dependent learning, and is open to collaborative learning environments.

Table 5: Student Epistemic Profile

X-Axis Perry Model	Y-Axis Theory of Knowledge	Z-Axis Self Regulation
1 Dualistic Binary problem solving Concrete world view Does not acknowledge multiple perspectives No critical analysis Motivation is extrinsic Does not see the "big picture" Intolerant to ambiguity	1 Knowledge is absolute Knowledge is based on scientific reasoning and natural laws	1 Low self-regulation Passive learner Faculty dependent learner Does not value collaborative learning
2 Relativistic Contextual problem solving Appreciates multiple world views Capacity for critical analysis Motivation may be extrinsic/intrinsic Sees the "big picture" Tolerant to ambiguity	2 Knowledge is relative Knowledge is based on practical applications	2 Moderate self-regulation Active/passive learner Faculty/student dependent learner Open to collaboration learning
3 Self-affirmative/committed Integrative problem solving Appreciates and incorporates multiple perspectives in the development of world view Employs highly cognitive, critical thinking skills Motivation is intrinsic Sees self in the "big picture" Embraces ambiguity	3 Knowledge is constructed and grounded in integrative, interdisciplinary perspectives	3 High self-regulation Active learner Student dependent learner Seeks opportunities for collaborative learning

Source: Dr. Michael Herndon, Virginia Polytechnic Institute and State University

Applying the rubric to identify applicable pedagogical strategies (Table 6) suggests initiation of some class discussion with an encouraging tone for students to participate in the discussions. Students should be encouraged to contribute to the base of knowledge and faculty should develop blended approaches for the dissemination of knowledge, such as a mixture of face-to-face instruction with online instruction. Moreover, faculty should utilize moderate cognitive learning strategies and develop assignments to diminish faculty responsibility for learning.

Table 6: Pedagogical Strategies

X-Axis Perry Model	Y-Axis Theory of Knowledge	Z-Axis Self Regulation
1 Faculty centered lectures Little to no class discussion	1 The faculty are the source of knowledge Synchronous dissemination of knowledge Controlled by faculty	1 Utilize low cognitive learning strategies Design only in-class learning opportunities Avoid an openness to change in instruction
2 Initiate some class discussion Encourage students to participate in class discussions	2 Allows faculty and students to contribute to the base of knowledge Develop blended approaches for the dissemination of knowledge (e.g. a mixture of online and face to face instruction)	2 Utilize moderate cognitive learning strategies Develop assignments to diminish faculty responsibility for learning
3 Foster robust class discussions Empower students with a large degree of ownership for the success of the class	3 The construction of knowledge is student driven Asynchronous dissemination of knowledge Create knowledge through peer learning (e.g., discussion boards, group projects, and other collaborative experiences)	3 Implement meta-cognitive learning strategies Encourage both in and out-of-class learning opportunities Develop assignments that facilitate the adaptability to change in instruction

Source: Dr. Michael Herndon, Virginia Polytechnic Institute and State University

Applying the rubric to determine the most appropriate assessment mechanisms (Table 7) for the student population indicates use of multiple choice test items. Student populations, as in this case, that have emerged from dualistic, binary thinking to relativistic in-context thinking can relate to multiple choice test items where relativistic thinking is assessed.

Table 7: Assessment Mechanisms

X-Axis Perry Model	Y-Axis Theory of Knowledge	Z-Axis Self Regulation
1 True/False Test Items	1 Assessment tools elicit rote responses from student	1 Student bears no responsibility for assessing individual progress
2 Multiple Choice Test Items	2 Assessment tools may encourage some degree of critical thinking and synthesis	2 Student takes some responsibility in gauging individual progress
3 Group case study research Utilizes peer reviewed exercises Makes use of simulation exercises	3 Assessment tools allow for the building of new knowledge created by the student	3 Active Learner Employs reflective writing assignments (e.g., e-portfolio, self authorship, and independent study) Student takes an active role in assessing individual progress, has a realistic appraisal of intellectual abilities and makes room for improvement by participating in co-curricular activities

Source: Dr. Michael Herndon, Virginia Polytechnic Institute and State University

Also, assessment tools and mechanisms should encourage some degree of critical thinking and synthesis to support an emerging sense of the contextual nature of knowledge. Moreover, this student population should take some responsibility for gauging individual progress through assessment mechanisms such as portfolio assessment, reflection and self-assessment, and comparative evaluations to one's peers.

7. FINDINGS AND RECOMMENDATIONS

This baseline study establishes a priori knowledge regarding the level of epistemic belief among a cross-sample of undergraduate Information Systems students. As seen in Figure 4, the student population demonstrates a moderate level of epistemic beliefs with respect to perceptions of knowledge and knowing (Q1-Q13), simple to moderate levels of epistemic beliefs with respect to self-regulation (Q14-Q32), and (increasing) moderate levels of epistemic beliefs with respect to self-efficacy (Q33-Q45).

Additional research is needed to establish longitudinal views of Information Systems students by year in school with subsequent assessment data collected to establish pre and post programmatic results as an indicator of improved levels of epistemic belief. In this case study, the student population demonstrates tendencies toward a trajectory to increased levels of epistemic beliefs.

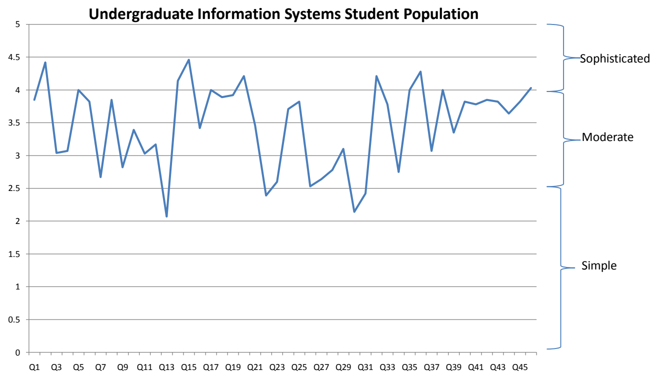

Figure 4: Item data graphed to illustrate levels of epistemic belief

Other general findings in support of conclusions include the need to alter and support learning environments, strategically align pedagogical strategies, and employ more appropriate assessment mechanisms in response to the Information System student population's current levels of epistemic belief. For example, learners in a collaborative problem solving environment receive feedback and comments from peers, and from the teacher on the steps of planning, implementing, and executing problem solving processes rather than only receiving feedback from the teacher on their performance. Therefore, peer pressure, as a motivating factor, may lead students to perform higher level cognitive functions. In addition, social constructivism (Pajares, 2002) suggests that the exchange of critical feedback among peers as well as from the instructor can encourage students to modify their work.

This study promoted the Scholarship of Teaching and Learning (SoTL) and extended the state of knowledge in Human Performance Technology by contributing to and exemplifying accepted learning theories and models. Students' perceptions of various aspects of teaching and learning in a course play an important role in their engagement and performance (Schommer, 1993). Ravert and Evans (2007) showed that expecting students at earlier stages of development to learn from courses based on principles of negotiation, shared construction, and peer-to-peer learning could be problematic. Therefore, if tools employed in teaching and learning or instructional design run contrary to students' epistemic beliefs, the result could be student frustration and distress. As a result, the instructional design and pedagogical strategy should address these issues during the course design phase.

In this report a study examining student epistemic beliefs was presented. The researchers offer the following suggestions for further discovery to faculty, instructional designers, and administrators who develop curricula for undergraduate Information Systems students entering college with undetermined levels of epistemic belief:

i. The authors suggest that faculty consider the use of epistemic belief data when developing course syllabi. Instructors should determine if the course design is structured in such a way to challenge and positively alter students' epistemic beliefs or only reinforce current epistemic beliefs.

ii. Epistemic beliefs among students were discussed in this research; however, examining the influence of faculty members' epistemic beliefs on students' epistemic beliefs is fertile ground for future research endeavors. Little to no scholarship has been devoted to this line of inquiry.

iii. This case study involved students in undergraduate Information Systems studies. The quantitative findings of this research may be generalized to students in multiple disciplines and year of study, as they relate to epistemic beliefs. Follow up study is needed to apply this methodology to broader boundaries.

iv. Faculty should apply the rubrics for student epistemic profile, pedagogy, and assessment in support of instructional design for Information Systems courses.

v. Research should further compare and study epistemic beliefs across disciplinary boundaries. The results will inform new efforts and planning phases in instructional design and curricula quality improvement initiatives.

vi. While the authors used one proven instrument to assess the epistemic beliefs in this case study, multiple tools exist. Course developers should choose an instrument that is most appropriate for their population and then apply the findings as was done in this case study.

vii. Finally, the authors suggest that the study of epistemic belief should occur in a longitudinal fashion. Institutions can gauge students' epistemic beliefs at the beginning of their first year and periodically assess shifts and trends among students throughout the undergraduate experience. This process can allow faculty members to fine tune course design, academic activities and assignments, and course assessments, promoting growth in academic performance among their students.

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Real World Projects, Real World Problems: Capstones for External Clients

Bryan Reinicke
reinickeb@uncw.edu

Thomas Janicki
janickit@uncw.edu

Information Systems and Operations Management
University of North Carolina Wilmington
Wilmington, North Carolina 28403 USA

Abstract

Capstones form an important part of the curriculum in many undergraduate and graduate programs in Information Systems. These projects give the students a chance to synthesize and apply the skills they have been acquiring throughout their academic program. These projects can be integrated with another recent initiative in higher education: service learning. By turning the capstones into "real-world" projects for external clients, the students can give back to the community while completing a valuable learning experience. However, these real world exercises sometimes take on real world characteristics – like failure. How do we, as professors, guide students through a service learning capstone to completion, despite the external challenges that come with it? How can we evaluate the outcome of these projects, when we know success may not be a part of the final product? The authors draw on personal experience with service learning capstones to address this problem.

Keywords: capstone, service learning, student learning, facilitation

1. INTRODUCTION

Capstone projects are popular at both the undergraduate and graduate level as a way to force students to integrate the information and skills they have learned from the various classes they have taken in their program (Morgan and Aitken, 2006). Some of these capstones take the form of classroom projects that can be more easily controlled by the instructor (Stillman and Peslak, 2009), while others deal with "real world" projects for clients outside the classroom (Scott, 2006, Reinicke and Janicki, 2010).

While classroom projects have the advantage of being easier to control, there is a recent push for service learning at many universities. The 2006 Model Curriculum for Graduate Degree Programs in Information Systems (Gorgone, Gray, Stohr, Valacich, & Wigand, 2006) recommends an integrated capstone experience.

Enhanced learning concepts are moving faculty to steer more students towards real world projects for external clients. These projects can be very rewarding for students and faculty. However, outside projects face the same challenges as those experienced by external organizations. This adds an additional level of complications to the projects for everyone involved, but it also provides some learning opportunities for the students.

Combining the capstone experience with service learning can provide an excellent way to both expand the students' knowledge of real world issues for systems projects and fulfill the universities push for service to the community (Lenox, 2008).

2. PROBLEMS WITH THE REAL WORLD COMPONENT

Combining service learning with a capstone experience provides a number of opportunities, but it comes with a number of challenges as well. The authors draw on experience with having worked with students on over 40 capstone projects for outside clients. The clients represented a mix of agencies on campus, area non-profits and even some small businesses. The problems that can be encountered in real world projects are numerous. These are some of the most common problems and some solutions for them.

These projects generally take the form of an integrated back end database to meet some reporting and input needs by the client. In some cases the projects need to integrate with existing systems.

The client doesn't know what they want!

Clients don't always know what they need or what they should expect from the system under development. While this is certainly frustrating for the students, it's also very much a real-world problem they will encounter in the work force. Clients in the real world will forget requirements, lack an understanding of technology and occasionally have difficult personalities.

This can serve as an excellent learning opportunity for students. We have frequently walked groups through what they can do with unclear requirements or what they can do with clients to try to crystallize requirements (i.e. prototypes, requirements documentation, asking for additional details on processes, etc.). While this is frustrating for the students, it does force them to actually apply the skills they (should) have learned in their systems analysis and design classes.

This can also pose problems for the professor guiding the project. Clients who are unclear on their requirements can reject systems when they decide that whatever the students produced didn't meet their rather ephemeral requirements. If this happens, we generally hold the students to their design documents. If they built what they said they would, and it works, then they have met the requirement for the capstone.

However, a difficulty here is that the client perceives that the students did not meet their needs (even though they did not define them initially), and the reputation and even future hiring from the university may be impacted.

Project creep also occurs. What starts out in the mind of the client and the student tends to grow. This is very real world, but when you are working in a one year or one semester time frame, management of this issue is immensely important.

Budget cuts?

In the real world, projects can be cancelled at any point due to a cut in funding. Even when the systems are being designed and built for free, the agency the students are working for can still find themselves short of funds. Depending on the timing, this can be very disheartening for the students. Especially if it happens early in the project, the students can lose some of their incentive to work on the project. The best approach found here is to tell the students that they'll be graded on the system they produce, and to point out that if they do a good job on it, their system will likely be the first thing implemented when the budget returns.

What do you mean you don't need it anymore?

Occasionally, a client will suddenly realize that they no longer need the system under development. This can happen because of a changing business environment, a change in priorities for the group or because of another initiative within the organization that provides duplicate functionality. Regardless, the students find out that whatever they develop will not be implemented because it's simply no longer of interest to the client.

While this situation can cause despair in the student groups, it can also create problems with the client. If the client no longer needs the system, they have less incentive to work with the students, and the students will require a fair amount of their time. While the authors have not personally experienced this problem with the clients (they are generally very happy to work with the students and understand that this is a learning experience for them), we have certainly seen this problem for the students. Generally speaking, it's good to tell the students that they'll be graded on the system they produce, regardless of the client's intention to implement it. Also, we have found that running an in depth "post mortem" on the project to find out what the students learned can be very helpful. This can help them focus on what they learned from the project, rather than focusing on the fact that their project will likely never see the light of day.

No one did it before! Where did that come from?

Student projects take time, but they do not operate in a vacuum. While they are working on their projects, the rest of the world continues to generate new systems and business ideas. While a given product or service may not have been available when the project started, it can certainly be there when they are done (or before).

The first author has only had this happen to one project, but it did present some interesting challenges. The student was working with a small business in the area on their idea for a new Internet based business, and midway through the one year project, another website came out that offered everything the business had been planning on offering, along with additional features. In this case, it was pointed out to the student that there are very few markets with only a single company in them – there is always room for competition. The student continued to work on the project, and while the small business ultimately decided not to pursue the opportunity; it was an excellent learning opportunity for the student.

I can't work with this person.

Group dynamics are problematic for every student group, which is also reflective of the real world. The students have to learn how to deal with difficult people, and this is generally something that is not covered in the curriculum. Thus, these projects can serve as a learning opportunity for this skill set.

If the problem is with another student in a group, there are a variety of ways to deal with it. One of the most common complaints in students groups is slacking, but this is something that can be dealt with in the structure of the projects. One solution for this problem is to have the students grade one another on the level of effort that they put into the project. This should constitute enough of the grade to have the students' attention, which provides the instructor with a way to lower the grade for those students who are slacking.

If this conflict is with the client, it poses a larger problem. Again, this is something that the students will have to deal with in the business world, so giving the student guidance here can be helpful. Some ways to deal with this are to encourage the student to find out which way is easiest to deal with the client (phone, e-mail or in person meetings) to try to reduce the friction and to find ways to get the information required with minimal contact. Depending on how bad the situation is, it may be necessary for the faculty member to mediate between the groups, but this should not be the first solution. After all, the students' future boss won't be happy about the fact that they have to mediate between their newest employee and their clients.

The client changed their mind…again!

Just as with any real world project, clients can be fickle. It's not unusual for the client to shift the scope for the project slightly (or greatly) as the students are working on it. While nothing can prevent the client from changing their mind early in the project, you can take steps to minimize the impact on the student teams later on. Specifically, having the students create a project charter or work agreement for the client (an excellent application of something they should have picked up in Systems Analysis and Design) and having the client sign it is a good way to prevent this from becoming an issue.

A word of caution based on experience. It's important to review the document before the students take the document to the client. There seems to be a tendency for the students to assume a great deal with the documents, rather than taking the time to spell out specifics. However, a vague project charter has doomed more than one real world project! The first author has found that going through a draft or two of the document before submitting it to the client to be beneficial, because you can force the students to go to a certain level of detail. The students are then required to keep a copy signed by the client and emphasize to them that this is their contract with the client for the work they need to perform (and will therefore be graded on).

The client wants me to solve world hunger.

With any real world project, the vision for the system can easily outstrip the available resources, and these types of projects are no exception. It's important to set realistic expectations with the client when you, the professor, are first discussing the project with them. It's also important to prevent "scope creep" from setting in once the students are on the project. Again, one of the most effective ways of avoiding this problem is to create scope documents for the project that are reviewed with the client, and then signed by the client and the students. So long as that documentation is there, and everyone has reviewed it, this problem can be minimized.

However, it has been our experience that some clients will push the students to add features, regardless of the documentation. Again, this is certainly something that they will see in the real world. In these cases, the instructor can remind the students that they will be graded on whether or not their final product fulfills the original scope of the project. If there is time at the end, they can add in the additional features, but in the meantime tell the client that your first priority is to meet the requirements laid out in the scope document. If the client continues to push, it may be necessary for the professor to talk to them directly about what is realistic for a student project.

We have found at times, that clients forget that these are student teams, and not 'for pay' consultants.

Time Allocation and Learning Curve of the Students.

In our situation the students receive only 6 credits over two semesters for the capstone project. For some of the projects this just isn't enough time for the students to learn new concepts of interviewing, design documents, story boarding, database design and implementation and a final production schedule.

This leaves the issue of what happens with 75% completed projects? Do we let the client hanging? The student has graduated!

We manage some of the client expectation by informing them that if the project is not completed by the agreed upon time, the next semester a high power team of students will complete the project.

How long did it take?

This is less an issue for the students than the professor. A common requirement for service learning initiatives is that the time the students spend on the project be tracked and reported to the university. A simple solution for this is to require the students, as part of the project, to submit time sheets.

This can be done either weekly or at the completion of the project. It has been our observation that the students are more accurate and attuned to this requirement if they have a weekly deliverable to turn in. We have also found it's best not to grade them on the number of hours spent; this leads to a rather predictable inflation of the hours spent on the project. Rather, we grade them on turning in a completed time sheet for the group every week and simply make it a small part of their overall grade.

Who will maintain the system?

At the end of the project, one of the questions that must be asked is who will maintain the completed system. This is less a burden for the students than for the professors who are running the class. Generally speaking, this requires some coordination between the faculty and the clients to transition the system to the clients. For our class, following a final presentation by the students at the end of the semester, the faculty member will work with the client to move the files to a server maintained by the client. Following this, it is the client's responsibility to put the system into production and maintain it. The department has a connection with a hosting service that works with nonprofit agencies if they need help with setting up and maintaining the system.

We have worked with the same clients repeatedly, where new student projects are enhancements to or extensions of existing systems completed by students in earlier semesters.

3. CONCLUSIONS

The twin demands of service learning and capstone projects can be combined beneficially, but there are additional challenges associated with combining these efforts. While combining these places additional demands on the students and the faculty responsible for the projects, this combination can provide valuable learning experiences for the students and can expand the university's presence in the community. However failure to manage both the client expectations and student progress may actually hurt the reputation of the university in the community.

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Expansion and Validation of the PAPA Framework

Belle Woodward
bellew@siu.edu

Nancy Martin
nlmartin@siu.edu

Thomas Imboden
timboden@siu.edu

School of Information Systems and Applied Technologies
Southern Illinois University
Carbondale, IL 62901, USA

Abstract

In recent years, ethics has drawn increased interest from information technology and computer science practitioners as well as from academicians. This article investigates the issues outlined in the PAPA framework in today's environment and explores the possibility that new issues have emerged. Findings indicate that the ethicality of property misuse may be viewed differently based on the level of personal risk, thereby offering a refinement of the original PAPA property issue.

Keywords: ethics, ethical dilemmas, unethical behavior, information technology students

1. INTRODUCTION

As society becomes increasingly entrenched in the digital information era, ethics in computing continues to be an important and widely discussed issue in both academia and practice. In 1986, Mason introduced four broad categories of ethical issues for the information age: privacy, accuracy, property, and access, otherwise known as PAPA (1986). More than twenty years later, those four issues are still timely and relevant. Mason's discussion centered on the personal harm that could occur from the unethical use of information and information technology (IT) within the framework of PAPA. In 1986, Mason could never have predicted that the computer would become not only the tool, but also the object, of such serious ethical transgressions as those that occur in today's networked world. However, his PAPA framework is still quite germane in studying ethical issues in IT. This research attempts to test the issues outlined in the PAPA framework in today's environment and to explore the possibility that new issues have emerged. This test and exploration is accomplished through the enhancement and validation of a survey instrument first introduced by Harris (2000).

2. BACKGROUND

Mason's (1986) seminal essay did not specifically define the PAPA issues as theoretical constructs, but rather launched each as an area of discussion and debate. Mason's concern for *privacy* was that an individual should be able to decide what personal information to hold private, what information to share, and be confident that shared information would be kept safe. The issue of *accuracy* focused on discussions of who was responsible for the accuracy and authenticity of information and what retribution was due to those injured by erroneous data. Mason's discussion of *property* addressed intellectual property rights, including those not necessarily protected by law. Mason also made reference to physical property such as the "conduits through which information passes" (p. 10). The final issue of the PAPA framework, *access*, dealt with the right or authority to obtain information.

Cadres of research in ethics and IT have been published since Mason's visionary essay in 1986. Several studies have considered one or a few of the PAPA issues, but only one known study attempted to measure or validate all four PAPA constructs. Using ethical dilemma scenarios, Conger, Loch, and Helft (1995) developed a 16 scenario/51 item instrument and surveyed 79 graduate business students. The analysis produced 12 factors which the authors grouped into five clusters. Two of the clusters aligned well with Mason's access and privacy issues. A third cluster aligned with Mason's property issue, but was better defined by the concept of *ownership*. A fourth cluster represented "*responsibility for accuracy*" (p. 25), a different perspective from Mason's concern with the impact of inaccuracy. A fifth cluster, *motivation*, represented an expansion the PAPA framework. While Mason offered a general discussion of victimization, Conger et al.'s motivation cluster reflected a recognized responsibility for actions that affect others.

More recently, Harris (2000) developed an instrument to measure student attitudes toward IT-related ethical dilemma scenarios. He found some evidence that sensitivity toward IT ethical issues increased as academic training increased. Harris also found support indicating that females may be more sensitive to IT ethical issues involving software use. Although it was not Harris' intention to measure the validity of PAPA constructs, his instrument questions were "roughly developed around Mason's PAPA" (p. 802).

Twenty years after Mason's ethical issues essay, Peslak (2006) surveyed more than 200 individuals and verified that the four original PAPA issues were still viewed as timely and important ethical concerns.

As part of a larger research endeavor, the primary objective of the current study was to determine if the ethical issues first delineated by the PAPA framework were still relevant and if other issues have replaced them. An additional objective was to explore any current issues that should be added to the PAPA framework. These objectives are important to IS educators so that ethics education can continue to evolve as the issues our students and future IT professionals are faced with also evolve.

3. METHODOLOGY

As noted by the prior studies, the use of ethical dilemmas or situations is an effective method of evaluating how students make ethical decisions (Cougar, 1989; Loviscky, Trevino, & Jacobs, 2007). After an extensive review of the literature, only the two aforementioned studies had used ethical dilemmas related to the PAPA issues. The survey instrument designed by Harris (2000) was selected as the basis to evaluate the ethical decision making of information technology students. Harris' survey is referred to as the Ethics in Information Technology (IT) Survey and was used with the author's permission. This instrument was chosen because it better reflects current ethical dilemmas facing students as well as professionals in the field.

Examples of the ethical dilemmas include such scenarios as using company email to send spam, copying software from work for personal use, and giving a non-student friend login access to university computing resources. The instrument has been enhanced from Harris' original and the detailed wording of the scenarios was published in an earlier study (Woodward, Davis, & Hodis, 2007).

The final survey contained 22 scenarios, some with multiple items for a total of 29 items. In the scenarios, an individual is presented with a situation and required to make a choice for a particular action. The students were asked to evaluate the individuals' responses to the situations presented. In some scenarios, respondents evaluated two party's actions, for example, the manager and the employee. Students were to mark an answer indicating whether the individual's action was ethical, acceptable, questionable, unethical, or computer crime. The categories are described as:

• Ethical - There is no question that the action is correct in every sense of the word. Ethically, morally, and legally, this is proper behavior.

• Acceptable - The action is acceptable to you, although you may have some doubts due to morals or other beliefs.

• Questionable - There is some question as to the moral or ethical aspects of the action. The action truly belongs in the "gray area" of human behavior.

• Unethical - The action is contrary to moral and ethical standards, although not a crime. This is truly unacceptable behavior.

• Computer Crime - The action is unethical and illegal, and the person responsible should be prosecuted for a criminal act (Harris, 2000).

IT students are an appropriate population since they are routinely faced with situations where they may be forced to make ethical decisions. Moreover, students have been shown to recognize PAPA issues as important when compared to professionals and others (Peslak, 2006). Additionally, younger populations, both students and younger professionals, have been shown to be more accepting of certain unethical behaviors such as the illegal copying and use of software (Kini, Ramakrishna, & Vijayaraman, 2004; Kruger, 2003; Peace, Galletta, & Thong, 2003). For these reasons, we selected undergraduate IT students for this study.

The survey was administered to undergraduate IT students in universities in four countries. Because ethics in IT is a worldwide issue, the inclusion of multiple cultures should contribute to the validity of any outcomes of the study. The comparative responses among the countries are being analyzed as part of the larger study and hence are not specifically addressed herein.

The survey was completed by 373 IT students: 198 from an American Midwest region university, 44 from a main British university, 51 from a main German university and 80 from a main Italian university. Of the total sample, 20% were female students (N=71) and 80% were male students (N=284). The average age of the respondents was 23.5. The total final valid sample was 355. The students participated voluntarily and were ensured of the confidentiality of their responses and all surveys were completed anonymously. The same instructor administered the surveys in all locations.

Data Analysis

To determine if an underlying structure of PAPA related factors exists in the survey items, exploratory principal component factor analysis was conducted. Because there was an apriori assumption that any resulting factors could likely be related, all dealing with ethical issues in IT, Promax, an oblique rotation method, was selected.

The subject to item ratio in this study was approximately 12:1, greater than the generally accepted 10:1 ratio for exploratory factor analysis (Costello & Osborne, 2005). The data were screened for multicollinearity concerns and review of the correlation matrix combined with an R-matrix determinant equal to .001 assured that multicollinearity was not a concern in the data. The KMO statistic for the data was .823 and Bartlett's test was highly significant, indicating factor analysis was appropriate for the data (Field, 2000).

Proceeding with a Promax rotation, a cutoff value of .30 was utilized as a minimum acceptable item loading (Hair Jr., Tatham, Anderson, Black, & Babin, 2006). The initial solution produced nine factors based on Kaiser's criterion of retaining factors with eigenvalues greater than one, explaining 60.22% of the variance in the data. However, nine factors led to interpretation difficulties because several factors displayed item cross-loadings and several contained fewer than three items. These conditions do not contribute to a "clean" factor structure (Costello & Osborne, 2005). Furthermore, the Kaiser criterion is considered one of the least accurate methods for selecting the appropriate number of factors (Velicer & Jackson, 1990). Therefore, we proceeded to interpretation of the scree plot. The scree test indicated an obvious break point in the data after four factors. To ensure proper selection, we analyzed the data creating three through nine factors, and the four factor solution produced the cleanest factor structure, even though the explained variance was reduced to 41%. Therefore, data analysis proceeded with a four factor solution. The resulting factor structure is displayed in Appendix 1.

4. RESULTS

Factor 1 contained 11 items with scores ranging from .816 to .333. The reliability of the factor was measured by Cronbach's alpha at .80, an acceptable level (Nunnally, 1978). Factor 2 contained 8 items with loadings ranging from .782 to .351. The Cronbach's alpha score was .793, also an acceptable level of reliability (Nunnally, 1978). Factor 3 consisted of 3 items with loadings in the range of .768 to .339. The reliability of this factor was weak at .430. Factor 4 contained five items ranging in loadings from .808 to .313. The Cronbach's alpha measure of reliability for this factor was also weak at .501. Although the fourth factor contained a variable, email checking, that loaded fairly evenly across three factors, the reliability analysis indicated that eliminating it from Factor 4 would lower the scale score. Hence, the variable was retained in the analysis. The items bank employee and inaccurate programming did not load onto any of the four factors.

Factor Interpretation

Low Risk Property Misuse: The 11 items in the first factor are related to the misuse of property, such as software and other computing resources. For example, making copies of software or using a company computer for personal business were issues in this factor. This category aligns with Mason's (1986) property issue and Conger et al.'s (1995) ownership category of ethical issues.

Interestingly, in the responses, the majority of students found these issues to range from questionable to unethical, but relatively few rated the actions as criminal even though obvious copyright infringement occurred in some of the scenarios. This factor may also represent a motivational aspect of property misuse, similar to the personal motivation factor that Conger et al. (1995) discovered. A common theme in the scenarios in this factor is the personal gain from the action and somewhat private nature of the behavior. It is possible that this factor represents the misuse of property where the risk of retribution is considered quite low. For these reasons, we labeled this factor *Low Risk Property Misuse*.

High Risk Property Misuse: The second factor consisted of eight items, most also reflecting issues of unethical or criminal behavior toward property. Some issues in this factor represented criminal trespass of property, such as the use of trademarks and patents. Other issues represented unethical or criminal actions, such as manipulating data or not reporting a software error.

A distinctive difference between the Low Risk Property Misuse factor and this factor was found in the student responses. While in the Low Risk Property Misuse factor, most respondents felt the issues were questionable or unethical, in this factor, most respondents felt the issues were at minimum unethical and at most criminal.

The items differed from the Low Risk Property Misuse factor in terms of possible motivators. Most of the items in this factor are related to actions on behalf of an organization, albeit some personally owned organizations, rather than action for individual gain. The scenarios that fell into this factor also appear to carry more risk than those in the previous factor. For example, the illegal use of a trademark on a website is quite a transparent violation that could easily be identified. Similarly, patent infringement is a risky action that might be discovered and litigated. Because the actions in this factor appear similar in their level of perceived risk as opposed to those in the previous factor, we labeled this factor *High Risk Property Misuse.*

Personal Responsibility: The third factor was rather unstable with a reliability score of .430 and should thus be interpreted cautiously. The issues in this factor seemed to reflect respondents' difficulty in determining true harm. For example, sending political spam from a company computer when there was no specific policy against it, or spreading a virus for the sake of experimentation were not clear cut ethical issues. The third item placed the actionable party once removed from the unethical behavior; she would create a website that would be used by the customer for unethical activity. These issues were intended to represent the responsibility of one's actions. Our *Personal Responsibility* factor most closely aligns with Conger et al.'s (1995) personal accountability category. Most student respondents found these three issues to be at best questionable and at worst unethical.

Privacy: The fourth factor consisted of five items all representing various facets of privacy. This factor displayed a weak reliability score at .501 and should be interpreted with caution. Examples of the scenarios include firing an employee for inappropriate web browsing and management monitoring of employee email. Labeled *Privacy*, this factor aligned with Mason's privacy issue and with Conger et al.'s (1995) category of personal privacy. The student responses were not as clearly categorized as in the other factors. The respondents felt that the actions of the managers fairly evenly ranged from ethical to unethical even when workplace policies were lenient or absent. They also reported that the employee's actions were unethical even considering a fairly lenient usage policy.

5. DISCUSSION

Keeping abreast of ethical dilemmas faced by our future IT professionals is of critical concern to IS educators. As technology rapidly advances, current and future professionals are faced with an ever-changing array of ethical situations. It is the duty of IS academia to continually evolve the IS ethics curriculum to keep pace with such changes. Because variations of the PAPA issues have stood the test of time, we attempted to validate and potentially update the PAPA framework as a guiding tool for both IS academia and IS professionals.

Mason's (1986) ethical issues of concern for the information age were *property, accuracy, privacy*, and *access*. Conger and her colleagues (1995) offered a more complex view of computer related ethical issues and categorized them into five subject areas: *ownership, access, motivation, responsibility*, and *privacy*. In our analysis, we derived four distinct factors, although two were related to property misuse. Our factors were *low risk property misuse, high risk property misuse, personal responsibility, and privacy.*

While both Mason (1986) and Conger et al. (1995) identified *property/ownership* as an ethical issue of concern, our results break down the issue into perceived risk levels associated with the maltreatment of property. Even though misuse is technically misuse, our results appear to delineate levels of "acceptable" property misuse at least within a limited cross-cultural student population. By uncovering this more precise view of property misuse, we believe we have expanded upon the earlier frameworks.

Our *personal responsibility* factor seemed to reflect the respondents' indifference toward their accountable actions when there was little policy or guidance in place, or when they were once removed from the final result of their actions. Mason's (1986) PAPA framework did not address this issue specifically. Though not a perfect match, our factor most closely aligns with Conger et al.'s (1995) *personal accountability factor* within their *responsibility* category. Because our factor displayed a cautionary reliability measure, as did Conger et al.'s, this particular ethical issue is a prime area for further exploration.

Our *privacy* factor, while weak in its reliability score, validates that this issue remains of key concern just as Mason predicted many years ago. We know that as Internet use grows, privacy continues to be a hotly discussed and debated topic. This ethical issue would be a good candidate for further refinement as well, possibly discerning between various levels of risk associated with personal privacy.

The low reliability scores for the *personal responsibility* and *privacy factors* are cause for further review. Perhaps the scenarios comprising these two factors were less clear cut to some of the respondents. Moreover, issues such as use of pornographic material may be viewed differently by different cultures. Further data analysis is needed to compare factor structures among the different countries.

Another possible explanation for the low reliability scores for the third and fourth factors is that perhaps there are really only a few dominant issues recognized by most students such as our varying levels of property misuse. Regardless of the reasons, it is clear that further refinement of the instrument is required.

6. LIMITATIONS AND FUTURE RESEARCH

As with any study, limitations must be acknowledged. In the current study, the use of students as survey respondents may have influenced the results. It is possible that even though participation was voluntary and anonymous, some students did not address the scenarios honestly or seriously.

Additionally, perhaps the translation of the instrument into different languages caused different groups to interpret scenarios differently. Further breakdowns and comparisons among the countries will be analyzed.

Another potential limitation is the research design. We chose to use ethical dilemma scenarios in order to build upon the work of other IS scholars. Perhaps a different approach would produce more enlightening results. For example, qualitative studies which include interviews with IT professionals might be warranted.

The authors plan to continue work in identifying and classifying current ethical issues. The instrument used in this study can serve as a starting point for enhancement, modification and retesting, and other approaches will also be investigated. Other researchers are encouraged to also enhance upon this work.

7. CONCLUSION

The PAPA framework established an important basis for considering ethical issues in our field. This study identified a valid refinement of the issue of property misuse and thereby informs those teaching in the area of IT ethics.

For educators, it remains clear that we have an obligation to teach our students how to be responsible IT citizens, both in the workplace and in their personal lives. With each refinement of the ethical issue agenda, we can utilize the results to enhance and further expand our ethics related pedagogies.

Our results also create implications for IT practitioners. It is important for IT professionals, especially managers, to understand that some employees might view computer related ethical issues based on their personal level of risk. For example, if no policy on personal email usage is in place, an employee might not see the harm in using company resources to send spam email for a good cause. It is important that organizations clearly define computing resource usage policies to prevent such actions.

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Appendix 1. Four Factor PCA Results

Scenario Item	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
copy of spreadsheet	**.816**			
word processing use	**.785**			
copy of software	**.701**			
shareware downloading	**.650**			
music download	**.595**			
company PC use	**.521**			
password leaking	**.450**			
unauthorized computer use	**.443**		.366	
making and selling	**.421**			
off-shore gambling	**.398**			
email employee	**.333**			
trademark stealing		**.782**		
patent leaking		**.751**		
abuse authority		**.670**		
patent violation		**.662**		
shareware virus		**.530**		
data manipulation		**.517**	.319	
error reporting		**.376**		
access to payroll record	.302	**.351**		
email sending			**.768**	
website creation			**.585**	
virus spread	.311		**.339**	
firing porn site user				**.808**
email manager			.310	**.531**
pornographic site user		.359		**-.515**
email checking		.436	-.439	**.463**
database leaking		.307		**.313**

Information Technology Diffusion: Impact on Student Achievement

Gregory M. Lee
glee@satx.rr.com
San Antonio College
Our Lady of the Lake University
San Antonio. TX

Mary L. Lind
lindm@ncat.edu
North Carolina A&T State University
Greensboro, NC

Abstract

For student achievement, the diffusion and adoption of information technology (IT) infrastructure enabled by special funding was posited to have a positive impact on student achievement. Four urban school districts provided the context for this study to assess the impact of IT adoption on standardized test scores.

Keywords: E-Rate, student achievement gap, IT diffusion

1. INTRODUCTION

A significant amount of funding has been allocated by the Federal Communication Commission on infrastructure for Information Technology access in education to address a crisis in student achievement (Wise, 2008). The causality of the Information Technology access impact on student achievement is unclear. The infrastructure spending has been on Internet access, telecommunications, cabling, switches, and routers primarily for urban impoverished K-12 school districts (Arfstrom & Sechler, 2006) in order to reduce the digital divide between poor and affluent school districts. Through the E-Rate program (Jaeger, McClure, & Bertot, 2005) schools and libraries can purchase Internet access and telecommunication services at a discount (Universal Services Administrative Company (USAC), 2009). The focus of this study is to address if the IT Infrastructure afforded by the E-Rate program has had an impact on the student achievement gap.

2. THEORY

The objective of this research is to discern the impact of the diffusion of information technology on education in poverty stricken urban school districts. Swanson and Ramiller (1993) in their study of information research thematics reveal that research questions on information technology diffusion relate not only to the adoption of technology but to information systems implementation and organizational outcomes. The topics dealing with IT diffusion accounted for 13.6% of the research papers submitted. Lee, Lee, and Gosain (2004) pointed out no dominant framework exists in IS research after ranking 31 theoretical frameworks. The top category, economic theory, ranked first at 11.5% while IT diffusion and technology determinism combined ranked fifth at 5%.

Diffusion theory can be traced back to Everett M. Rogers' book, *Diffusion of Innovation,* first released in 1962. In its fifth edition (2003), Rogers defines diffusion as a process or a set of ideas that is disseminated through channels to members of a social system over a specified period. Rogers notes technological innovations have some benefits for potential adopters but the advantage is not as apparent to the intended audience. According to Rogers, diffusion transitions through five stages: knowledge, persuasion, decision, implementation, and confirmation. Closely associated with diffusion theory is the technology adoption model, pioneered by Fred Davis in 1989. The model outlines two basic parameters for adopting technology: perceived usefulness and perceived ease of use (Davis, 1989).

3. THEORETICAL BASIS of IT DIFFUSION

E. M. Rogers, a pioneer in classic diffusion theory, known for his book, *Diffusion of Innovation,* published in 1962, defines diffusion as a process in which an idea or innovation is communicated via a social network. Adoption or acceptance of an idea or process is dependent on the importance of the idea and space and time of the idea. The researcher insists adoption rate variance can be explained by five attributes: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). Relative advantage is a perception that a new idea or concept is better than an existing or older one. Compatibility is the degree to which a user perceives an innovation as being consistent with his or her world experiences. Complexity is a user's perception that an innovation is difficult to use and understand. Trialability is the degree to which an innovation can be tested before adoption. Observability is the degree to which an innovation appears to others. Four other attributes are important for rate of adoption: type of innovation, nature of communication channels diffusing the innovation, nature of the social system, and extent of change agent influence in diffusing the innovation.

Rogers categorizes adopters as innovators, early adopters, early majority, and laggards based on the rapidity of their adoption of a new idea, concept, or innovation. The researcher notes that computer networks have the capability to empower the underdogs of society. Rogers states the Internet has fueled interest in the study of diffusion in the analysis of communication networks in the diffusion process. Rogers contends computer networks have grown exponentially since 1990. The author credits this growth to the formation of the Internet. The Internet grew from 20 million computers in 1995 to over 500 million in 2002. The Internet represents the fastest diffusion or adoption rate in the history of humankind. Closely related to diffusion is user acceptance.

Davis (1989) researched factors associated with user acceptance of information technology. The researcher was interested in what caused users to accept or reject information technology. Davis focused his attention on two variables: perceived usefulness and perceived ease of use and concluded that perceived ease of use was the dominant factor.

Jeyaraj, Rottman, and Lacity (2006) examined the body of research on IT diffusion and adoption by individuals and organizations. They analyzed 48 empirical studies on individual and 51 studies on organizations published from 1992 to 2003. Their research showed the best predictors for individual IT adoption are perceived usefulness, computer experience, top management support, behavioral intention, and user support. The best predictors for organizational IT adoption are support by top management, external pressure, external information sources, and professionalism of the information systems division.

Not all researchers subscribe to the theory of diffusion. McMaster and Wastell (2005) dispute the concepts of diffusion as espoused by Rogers and other authors. Rogers (2003) defines diffusion as a process where innovation is communicated via various paths among members of a social system. The researchers contend the diffusionist view of the world is elitist where one distinguishes laggards from innovators thus creating a class distinction. They vehemently criticize the notion that there are a few innovators and that most people are imitators. This notion is central to diffusion theory. While the authors bring up some salient points, some of their points are extreme. They compare diffusion theory to early European colonialism. They contend there is no empirical support for diffusionism and that it has no basis in fact.

4. IT DIFFUSION RESEACH AND STUDENT ACHIEVEMENT

Schacter (1999) outlined the current research at that time regarding the impact of educational technology on learning. The author used the case study methodology in his paper. The report covered research on student achievement from 1994 to 1999. The document was published in 1999 and covers some of the large-scale state and national studies of that period. It also covered some of the innovative smaller studies such as the Apple Classrooms of Tomorrow (ACOT) and the Learning and Epistemology Group at MIT that provided insight for new and effective uses of technology in learning and instruction. The study highlighted by Schacter generally showed an increase in student achievement but not in all areas.

Cuban et al. took a contrary view by questioning the premise that buying technology such as hardware and software for schools will lead to high use by teachers and students thus improving teaching and learning. The researchers did a quantitative analysis of surveys and interviews of 21 teachers and students at two high-tech schools in Silicon Valley near San Francisco and San Jose, California. They observed the student to computer ratio had improved in public schools from 92 students to one computer in 1983-1984, to 27 students to one computer in 1989, and to 6 students to one computer in 1999. They also noted a similar trend in wiring of schools for Internet access, 3% in 1994 and 90% in 1999. The researchers' found that three-fourths of the teachers in both schools were non-users of technology in their curriculum as indicated by the use of media center resources in each school. Students reported low-level use such as word processing and Internet searches. Cuban et al. attempted to explain this paradox in two ways: "slow revolution" or slow adoption of technology and context of the high school that has historically been teacher-centered with established and difficult to change practices. They suggested that fundamental changes are needed in teaching practices in order to allow the diffusion of technology in schools.

D'Souza and Woods (2003) outlined the need for more technology when they examined the attitudes of students concerning the infusion of technology into mathematics at a secondary school in Australia. They contended that literature on the use of computers varied. They believed that technology should be integrated into education since the technology had become an essential part of society. The researchers used surveys of 95 Australian students for their study. The mathematics students in the study resisted new technology because there were too few working computers, computers not working properly, the difficulty of learning new software, and fear or lack of confidence using computers. The researchers concluded in order to have a successful technology implementation there should be adequate computer resources and training for students and teachers when developing a new curriculum.

Fuchs and Woessmann (2004) found a lack of IT diffusion involving student achievement and computer use at school. The researchers examined the relationship between student achievement and the employment of computers at school and at home. They based their study on an international student assessment test. The researchers employed the quantitative approach and concluded that computers produced a positive outcome in student achievement. Fuchs and Woessman analyzed the dataset from the Programme for International Student Achievement (PISA). The PISA is an international achievement test conducted in 2000 of 15-year-old students. The test was sponsored by the Organization for Economic Co-Operation and Development (OECD). The results of their analysis revealed after factoring in family background and school characteristics, the relationship is negative for student home computer use and is insignificant for student computer use in school.

Wenglinsky (2005) received mixed results on the issue of whether technology in school improves student achievement. The researcher employed the National Assessment of Educational Progress database and survey results to ascertain the link between computer use and student test performance. In the new study, based on 12^{th} grade students' performance on the U.S. history assessment, technology was not the most relevant factor. Socioeconomic status and student use of computers at home were more important determining factors. Wenglinsky found more frequent student use of computers at home for school work correlated to higher scores on the history assessment. The researcher found the opposite from computers used in schools. The author concluded in this study that using technology does not automatically translate into higher performance on an assessment. The researcher suggested that schools need to teach not only basic computer skills but also technology skills needed for future white-collar jobs.

On the issue of IT diffusion, Simpson, Payne, and Condie (2005) found teacher attitude was critical. The researchers discussed the effect of information computer technology (ICT) in secondary schools. The study was conducted on schools in Scotland. Scotland has invested large sums of money for technology in their school systems but had not seen the rewards of this investment. The researchers used surveys and semi-structured interviews as the methodologies to collect data. Although 75% of the schools had ICT committees, the committees did not have the power to enforce their recommendations. Attitude was a key factor for the lack of ICT integration. The finding by the researchers was that teachers did not want to engage with colleagues or with information outside of their profession regarding the technology. In addition, they noted teachers preferred face-to-face encounters for disseminating and receiving new information, the subject area head was the decision-maker in any subject matter, and the reluctance of the departments to change. A key finding was the autonomy of individual teachers in rejecting efforts to integrate technology into their curriculum. All of these reasons pointed to possible reasons for the lack of diffusion of ICT in the secondary school systems.

Norris, Sullivan, Poirot, and Soloway (2003) studied the impact of IT diffusion in kindergarten to 12th grade (K-12). The researchers used the case study methodology and surveys for their research tools. They analyzed 3,665 teacher responses collected from late 2000 and early 2001 from California, Florida, Nebraska, and New York. They surmised from their Snapshot Survey that 14% of U.S. K-12 teachers did not use computers at all for instructions, 45% used computers less than 15 minutes a week with students, and 18% of teachers used computers for instructions more than 45 minutes a week. Their survey also revealed that two-thirds of teachers used the Internet with students less than 15 minutes a day. The teachers surveyed stated the lack of available computers as the reason for little or nonuse of computers. The researchers deduced it would take at least six computers per classroom to effectively solve the problem. In addition, they noted the intermittent use of computer laboratories had no positive impact on technology adoption. They argued the low use of the Internet was directly tied to a lack of computer resources. In their concluding remarks, Norris et al. (2003) refuted the argument that a lack IT diffusion in schools is based on teacher attitude. They state emphatically that teachers' use of technology is based almost entirely on their access to technology.

Staples, Pugach and Himes (2005) differed with Norris et al. in their study of three urban elementary schools in the Midwest given identical resources in order to document the integration of technology. They used qualitative research methods to examine how technology resources made available through a grant were used. Although the principals voiced commitment for implementing technology and professional training was provided, the teacher commitment to technology integration in the classroom was tentative. The findings by the researchers were that technology must be aligned with the curriculum, teacher leadership was important to getting technology acceptance, and there must be recognition for students and teachers who embraced technology.

Schrum (2005) points out that despite the introduction of advanced technologies in schools; there has been minimal impact on school reform. The author claims business, medicine, and entertainment have evolved because of the digital revolution while schools have demonstrated sporadic progress. Schrum contends effective returns for future educational investments is possible if research captures past impact and paves a path for future use. The author strongly argued there has been no documented systematic increase in student achievement linked to technological innovation. Schrum attributed this to three factors: unrealistic expectations for technology-based reform, lack of consensus on research questions and methodologies, and diminished role of research in school reforms. The author recommended research focused on research questions not yet articulated, realistic expectations for instructional strategies, and a more focused research agenda.

Azzam (2006) disagreed with Schrum that technology had minimum impact on school reform. Azzam touted the benefits of technology-enabled opportunities. The author suggested that technology had the potential to improve student achievement. Azzam also suggested students with digital skills will do better in the job market. Statistics were cited that indicated Asian American and white young adults have double the access to the Internet than poorer ethnic groups. The author did not provide information on linkage of Internet to student achievement. The author however recommends that society invest in technology, create benchmarks, and ensure all children have access to technology at home, in the community, and at school. March (2006) however warned that the unsupervised use of the Internet has the potential for more harm than good for students. The author stated the "whatever and whenever" mentality induced by the Internet does not lead to happiness nor meaningful actions by students. Young adults wanting to avoid stress or boredom turn to the Internet for a distraction from real life. March claims this can lead to addiction to the Internet. The author advocated a strategy for all teachers that involved building a web portal to attract student interest and involvement in the more positive educational aspects of the World Wide Web.

Wan, Fang, and Neufeld (2007) presented an integrated framework of technology-mediated learning research and highlighted the information technology component and its effects with other factors. They broadly defined information technology in their study as computing, communications, data management technologies, and their convergence. The researchers focused their research on four groups of relationships that involve IT: (1) the relationship between IT and students and teachers; (2) between IT and instructional design; (3) between IT and the learning process; and (4) between IT and learning outcomes. Wan et al. (2007) concluded information technology was an important part in diverse learning environments. The researchers recommended the need for research in several areas: (1) using non-student research subjects, (2) exploring the social nature of learning, (3) examining IT infrastructure and its effect on the learning environment, (4) investigating the applicability and efficacy of new learning models, and (5) examining learning processes and how they are facilitated by IT.

5. TECHNOLOGY AND THE DIGITAL DIVIDE

The digital divide refers to those that have access to technology and those that do not have access primarily because of an economic and social gap. Kennard (1999) called for federal support to reduce this divide when he was the chairperson of the Federal Communications Commission (FCC). With implementation of the Telecommunications Act of 1996 the FCC was directed to bring advanced technology to the nation's public schools and libraries. In 2004 Jayakar discussed the success of this initiative in term of the education rate (E-Rate) of these initiatives targeted at low income applicants, high cost areas, rural health care providers, and libraries mandated by Congress in the 1996 Telecommunications Act in order to bridge the technology gap between rich and poor communities. Schools received discounts ranging from 20 % to 90 % based on the number of their students enrolled in the national school lunch program. Then this money was spent on IT infrastructure such as telecommunication services, the Internet, and internal wiring or cabling. This successful program resulted in an investment of $1.7 billion in information technology infrastructure in over 80,000 schools.

Research has been mixed concerning the linkage of IT on student achievement and inconclusive on whether the E-Rate program has improved student achievement or narrowed the digital divide. Some researchers question the value of IT on student achievement (Cuban, Kirkpatrick & Peck, 2001) and question the assertion that buying technology such as hardware and software for schools will lead to effective use by teachers and students thus improve the learning environment

Ward (2005) analyzed the E-Rate program in Texas and its impact on public schools from 1994 to 2003. Ward's (2005) study revealed more teachers were allocated to E-Rate subsidy schools than non-E-Rate schools and the overall average college entrance scores (ACT and SAT) of E-Rate schools dropped. Ward theorized that the E-Rate subsidy motivated schools to encourage more marginal students to take the college entrance exams thus triggering a drop in average college entrance scores.

On the other hand, Arfstrom and Sechler (2006) laud the results of ten years of the E-Rate program. The authors point out the E-Rate program has provided almost $19 billion to schools and libraries. They claim that the E-Rate has been responsible for increasing Internet access in public schools from 14 % in 1996 to 94 % in 2005.

There has been little empirical research ascertaining whether the E-Rate program by providing better IT infrastructure improvements in impoverished urban school districts has narrowed the digital divide and has improved student achievement as measured on standardized nation-wide tests. Recently, the Government Accountability Office [GAO] reported the Federal Communications

Commission (FCC), which monitors the E-Rate program, lacks adequate performance goals and performance measures (U. S. Government Accountability Office (GAO), 2009).

There are very few current studies that link technology diffusion in secondary schools to student achievement as measured on a nation-wide standardized test such as the SAT or ACT. The studies that do exist are dated, very limited in scope, lack generalization, or lack empirical validation (Cuban et al., 2001; Goolsbee & Guryan, 2006; Schacter, 1999; Simpson et al., 2005; Ward, 2005; Wenglinsky, 2005). In addition, results of research on IT diffusion in education have been inconclusive. Chin and Marcolin (2001) argue success measures linked to diffusion should be the focus of future research and there needs to be a tighter relationship between diffusion and its performance impact. Schrum (2005) strongly articulates the need for focused research in this area since there has been no documented systematic increase in student achievement linked to technological innovation. This study (Lee and Lind, 2010) will discern whether there is an impact, linkage or correlation between IT funding levels and student achievement. The research will also add information to the debate on whether there is a correlation between IT diffusion and student achievement.

The literature is inconclusive on the effect of IT diffusion or adoption in an educational environment. Schacter (1999) found that IT diffusion was sufficient to improve student performance in an educational setting. Early research by Cuban, Kirkpatrick and Peck (2001) disagreed with Schacter's findings and suggested the infusion of technology (computers and wiring for Internet) into high schools had no effect on student achievement. Similar findings were supported by Simpson, Payne and Condie (2005) in their case study of secondary schools in Scotland and by D'Souza and Wood (2007) in their case study of secondary math students in Australia. Wenglinsky (2005) directly associated the use of technology to student achievement but his results were mixed. Norris, Sullivan, Poirot, and Soloway (2003) in their study of the impact of IT diffusion in kindergarten to 12th grade (K-12) found the lack of IT resources was a detriment to IT diffusion not teacher attitude. This study will add to the body of knowledge on the dynamic nature of IT and student achievement.

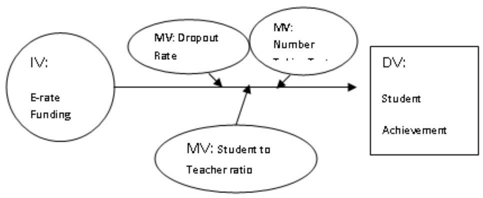
The FCC and other federal agencies that allocate monies to schools, specifically the E-Rate program, should know which programs are effective and which ones are not. This study is significant since massive amounts of federal monies are funneled to poverty stricken urban school districts for IT infrastructure each year with the inferred hope that it would spur student achievement. The GAO reports reveal a lack of accountability in this area. This study provides an initial baseline for assessing the effectiveness of the E-Rate program.

6. THE STUDY

For this study, information was obtained on IT federal funding to school districts over the last twelve years from the FCC through the E-Rate program. The study centered on school districts primarily in Los Angeles, California, Chicago, Illinois, Philadelphia, Pennsylvania, and Houston, Texas so the study could be generalized to other urban school districts throughout the United States receiving E-Rate funds. Test scores for students were collected from these selected school districts from the California Department of Education, Texas Education Agency, Illinois Department of Education, Pennsylvania Department of Education, and National Center for Education Statistics (NCES) as appropriate. To discern student achievement, the study measured scores in urban impoverished, affluent, non-impoverished schools as well as impoverished school districts to determine if changes that occur in each are similar or different. Since the four largest urban school districts are basically classified as urban impoverished entities based on their high percent of students in the free and reduced lunch (> 75%), four affluent school districts with a low percent (<15%) of students in the free and reduced lunch were selected for comparison. This served as a baseline of comparison.

Other collocated school districts (86) classified as impoverished and non-impoverished were analyzed in the study to determine if they followed similar patterns. School size, teacher to student ratio, and dropout rate were considered since they were potential moderating variables in the study (see Figure 1). Socioeconomic factors were accounted for by identifying the percent of students in each school district eligible for the federal free and reduced lunch program. In the quantitative study, the E-Rate funding was the independent variable, student achievement was the dependent variable, and number of students taking test, dropout rate, and student-to-teacher ratio were the moderating variables (Figure 1).

Figure 1 Research Model



7. RESEARCH DESIGN

The units of analysis for the study are the identified school districts. School districts were selected because E-Rate funding is primarily allocated by school district rather than individual school. School districts were selected because a more detailed analysis of student achievement based on the SAT and ACT is possible. There were several sources of data for the proposal. The first source was the U.S. Department of Education National Center for Education Statistics (NCES). This site contains information on student/teacher ratio and information on school districts (Institute of Education Sciences (IES), 2009). This information is online and free. The second sources of data were the Scholastic Aptitude Test (SAT) and American College Test (ACT). Information on aggregate school district SAT and ACT scores were obtained from the California Department of Education, Illinois Department of Education, Pennsylvania Department of Education, and Texas Education Agency Web sites. The third source of data was FCC's Schools and Libraries Division (SLD) information site at http://www.e-ratecentral.com/. This site contains information on which libraries, school districts, and schools have qualified and received IT infrastructure funding. The E-Rate discount rate based on a school district's free and reduced lunch program eligibility is available. The site also contains information on how the E-Rate funds are distributed for internal connections (cabling and equipment), Internet access, and telecomm (telephone service and wide area connectivity). A baseline for student achievement was established by assessing scores in urban impoverished, affluent, impoverished, and non-impoverished school districts to form a baseline for comparison. This process was accomplished by comparing school districts with a low percent of students in the national free and reduced lunch program to those with a higher percent in the program. The E-Rate program has traditionally fully funded urban school districts at the 80% or more free and reduced lunch eligibility level but has rarely fully funded those at the 20% or less level (E-Rate Central, 2009). Based on this observation, urban impoverished school districts were classified as those that have 80% or more students eligible for the free and reduced lunch program. Similarly, affluent school districts were defined as those that have less than 20% of their student population eligible for the free and reduced lunch program. The primary sources of information for free and reduced lunch data were the state educational web sites (California Department of Education, 2009; Illinois State Board of Education, 2009; Pennsylvania Department of Education, 2009; Texas Education Agency, 2009) and the SLD.

8. SAMPLE/DATA COLLECTION

The sample size for the school districts in the study was the eight primary urban impoverished and affluent school districts and the 86 collocated school districts near or within the same county as the major urban school districts. The 94 school districts in the study represented 801 high schools. The four urban impoverished school districts accounted for 411 or 51.3% of all high schools. The additional collocated school districts had the potential to refute or support findings from the initial sample. In addition, the collocated school districts were used as a control group to contrast any differences. The major urban impoverished school districts were Los Angeles Unified School District (SD), Chicago Public Schools, School District of Philadelphia, and Houston Independent School District (ISD). The selected affluent school districts were Irvine Unified SD in Irvine, CA, Central Bucks School District in Doylestown, PA, Clear Creek ISD in League City, TX, and Glenbard Township School District in Glen Ellyn, IL. Each of the selected affluent school districts had an average free and reduced lunch eligible population of less than 15% while the urban impoverished districts' numbers ranged from 75% to more than 90% (California Department of Education, 2009; Illinois State Board of Education, 2009; Pennsylvania Department of Education, 2009;

Texas Education Agency, 2009). All of the school districts were analyzed to discern changes in achievement gap. In order for the study results to be generalizable, geographically dispersed urban school districts were selected from the West (Los Angeles Unified), Midwest (Chicago Public Schools), East (The School District of Philadelphia), and Southwest (Houston ISD). All of the selected impoverished school districts are among the ten largest in the U.S. (Institute of Education Sciences [IES] National Center for Education Statistics, 2009). Each state where these districts are located is also an active participant in the E-Rate program (E-Rate Central, 2009). Some of the information such as the number of students testing was derived from raw data.

While the school districts selected were not completely random nevertheless the study should have reliability and validity for other urban school districts meeting the same or similar criteria. The California Department of Education, Chicago Public Schools, Illinois Department of Education, Pennsylvania Department of Education, and Texas Education Agency provide historical ACT and SAT scores for school districts to the public for research and other purposes therefore approval was not required from the College Board nor ACT, Inc. The strength of this strategy is the study employed data already collected by the SLD, educational entities, and National Center for Education Statistics.

9. DATA ANALYSIS

The study employed a pretest-posttest design to discern any changes between the groups based on the E-Rate program. Specifically, the study used the Solomon four-group design which permitted the authors to analyze the magnitude of effects caused by pretesting, history, maturation, and treatment. The pretest groups were the urban impoverished, affluent, impoverished, and non-impoverished groups before the effects of the E-Rate program (1997-2000). The posttest groups were the same groups after the effects of the E-Rate (post 2000). The study employed the analysis of variance (ANOVA) on gain scores. The study used descriptive statistics to analyze school size, school district student to teacher ratio, dropout rates, assessment tests, and E-Rate data. Then correlation and regression analysis was used to test the hypotheses. The results of the study ascertained the level of impact of E-Rate federal funding on student achievement and the achievement gap. It also discerned whether there was any moderating factors based on the variables identified that affected this result.

10. METHODOLOGY

The period for the study was 1997 to 2008. The four groups were urban impoverished, affluent, impoverished, and non- impoverished. The pretest period was 1997 to 2000. Although the Schools and Libraries started dispensing funds in 1998, some major school districts such as the Schools of Philadelphia did not take advantage of the program until 2000. In addition, according to previous research by Goolsbee and Guryan (2006), there can be a significant lag time before the results of E-Rate funding materialize. Based on this research E-Rate results would be expected two or more years after funding because of implementation of the IT infrastructure and integration into the school district’s curriculum.

Pre-E-Rate Analysis

Using SPSS, a bivariate correlation was run on the variables for the pre-E-Rate group (1997-2000). There was a significant negative correlation of -.231, -.248, -.234 and -.250 at the 0.05 level between school size and SAT scores for 1997, 1998, 1999, and 2000. This indicated the larger the school district, the lower the SAT scores. There was a significant negative correlation of -.672, -.699, -.703, and -.700 at the 0.01 significance level for E-Rate discount and SAT scores for 1997, 1998, 1999 and 2000. This suggested socioeconomic factors based on the free and reduced lunch program were negatively correlated with SAT scores. Student to teacher ratio and number of students tested while slightly negative did not exhibit significant correlation with SAT scores. Number of students testing was correlated with the E-Rate discount at the 0.05 significance level at .234, .232, .226 and .212 for 1997, 1998, 1999 and 2000 respectively. These results show a higher E-Rate discount was positively related to the number of students testing. This supported Ward’s observation that higher E-Rate funding levels stimulated a higher number of students testing. Number of students testing however was not correlated with SAT scores at a significant level. Dropout rate was significant and negatively correlated with SAT scores. The 1997 dropout rate was correlated with SAT97, SAT98, and SAT99 at the 0.01 significant level at -.605, -.605, and -.585 respectively. The 1998 dropout rate was correlated with SAT98 and SAT99 at the 0.01 significant level at -.520 and -.566 respectively. The 1999 dropout rate was correlated with SAT99 at the 0.01 significant level of -.637 and 2000 dropout rate was correlated with SAT00 at the 0.01 significant level of -.633. These results suggest school districts with higher dropout rate have lower SAT scores. Dropout rate also relate to socioeconomic factors.

The One-Way Analysis of Variance or ANOVA was used to analyze the data since the study involves examining the sample means of SAT scores for different categories of school districts receiving E-Rate funds and drawing conclusions about the resultant SAT means. The ANOVA requires the data to be independent and normal with equal variances (Norusis, 2008). The data for each district is independent since SAT scores are not dependent upon scores in other districts – this was examined with histograms and boxplots available from the 1st author.

The Levene's Test of Homogeneity was employed to determine equal variance. Large significances above .5 show equal variance (Norusis 2008). Table 1 shows equal variance for most of the years of SAT testing. The df1 or degrees of freedom one (3) is the number of categories (4) minus one. The df2 or degrees of freedom two is the total number of districts (94) minus four, one from each category. The requirements to proceed with ANOVA are fulfilled by SAT scores being independent and normal with equal variance.

Table 1. ***Test of*** **Homogeneity** ***of Variances***

	Levene Statistic	df1	df2	Sig.
SAT97	2.959	3	90	.037
SAT98	1.554	3	90	.206
SAT99	1.654	3	90	.183
SAT00	.772	3	90	.513
SAT01	2.490	3	90	.065
SAT02	.550	3	90	.649
SAT03	.987	3	90	.403
SAT04	.424	3	90	.737
SAT05	.192	3	90	.902
SAT06	.338	3	90	.798
SAT07	.197	3	90	.898
SAT08	.802	3	90	.496

The One-Way ANOVA run on the pre-E-Rate (1997-2000) dataset revealed F=25.363 at sig=.000 for SAT97, F=25.127 at sig=000 for SAT98, and F=25.972 at sig=.000 for SAT99, and F=25.001 at sig=000 for SAT00. The significant values demonstrate the mean comparisons were significant for 1997 through 2000. The Post Hoc Test confirms this observation. The Post Hoc Test reveals some noteworthy comparisons. The mean comparison for SAT scores between urban impoverished and affluent districts (primary groups) was -223.25, -229.75, -230.0, and -238.0 significant at the 0.05 level for SAT97, SAT98, SAT99, and SAT00 respectively. The mean comparison between the impoverished and non-impoverished districts was -111.791, -117.047, -127.488 and -120.558 significant at the 0.05 level for SAT97, SAT98, SAT99, and SAT00 respectively. The trend demonstrated a slow but widening gap of SAT scores between urban impoverished and affluent districts between 1997 and 2000 where the gap widened from -223.25 points to -238.0. A similar trend was noted between impoverished and non-impoverished districts where the gap widened from -111.791 in 1997 to -120.558 points in 2000.

Post E-Rate Analysis

Table 2. ***Correlation of E-Rate Funding and SAT Scores***

	SAT01	SAT02	SAT03	SAT04	SAT05	SAT06	SAT07	SAT08
E-Rate98	-.306**	-.291**	-.173	-.260*	-.243*	-.219*	-.236*	-.229*
E-Rate99	-.306**	-.299**	-.180	-.263*	-.249*	-.227*	-.240*	-.233*
E-Rate00	-.320**	-.324**	-.197*	-.280**	-.276*	-.254*	-.255*	-.247*
E-Rate01	-.288**	-.259*	-.165	-240*	-236*	-.228*	-.226*	-.234*
E-Rate02	-.303**	-.287**	-.179	-.280**	-.282*	-.256*	-.275**	-.255*
E-Rate03	-.245*	-.221*	-.147	-.226*	-.221	-.211*	-.232*	-.217*
E-Rate04	-.277**	-.267**	-.169	-.252**	-.253	-.230*	-.233*	-.224*
E-Rate05	-.269**	-.255*	-.153	-.229*	-.223*	-.213*	-.234*	-.219*
E-Rate06	-.308**	-.297**	-.180	-.266**	-.255*	-.241*	-.259*	-.247*
E-Rate07	-.227*	-.209*	-.126	-.191	-.181	-.177	-.195	-.188
E-Rate08	-.281**	-.258**	-.164	-.245*	-.241*	-.233*	-.258**	-.239*

**. Correlation is significant at the 0.01 level (2-tailed0
*. Correlation is significant at the 0.05 level (2-tailed)

Bivariate correlation of variables was run on the post-E-Rate (2001-2008) dataset. This dataset included E-Rate funding. The correlation results revealed similar findings on school size, and E-Rate discount, and SAT scores. Large district size was negatively correlated with SAT scores. The E-Rate discount indicated socioeconomic factors based on the free and reduced lunch program correlated negatively with SAT scores. Student to teacher ratio and number of students tested while slightly negative did not exhibit significant correlation with SAT scores. The number of students tested was positively correlated with E-Rate funding at the 0.01

significance level for 2001 to 2008, varying from .535 to .931. These results show that higher E-Rate funding was positively related to the number of students testing. There was a negative correlation between E-Rate funding and SAT scores from 2001 to 2008. This summary information is highlighted in Table 2.

These results can be interpreted several ways. One researcher (Ward, 2005) suggested that E-Rate funding had a negative impact on SAT scores because it motivated more students to test. Another interpretation is that larger E-Rate funding went to school districts that traditionally score lower on the SAT test versus more affluent or non-impoverished school districts with less E-Rate funding.

Table 3 shows the mean SAT scores for each category of school district from 1997 to 2008. There has been little change in each category. Urban impoverished school districts had a period from 2003 to 2008 where there was minor SAT improvement of .69%, .57%, .46%, .58%, .58%, and 1.04% respectively from 1997. This was a change from a steady decline of from 1997 to 2000 of -.115%, -.347%, and -1.042 in 1998, 1999, and 2000 respectively.

Table 3. ***Mean SAT Scores 1997-2008***

Year	Urban Improv	Affluent	Impov	NonImpov
1997	864	1087	932	1044
1998	863	1092	935	1052
1999	861	1091	925	1052
2000	856	1094	924	1044
2001	859	1078	920	1063
2002	860	1080	918	1054
2003	870	1089	900	1054
2004	869	1091	926	1057
2005	868	1091	928	1061
2006	869	1098	923	1049
2007	869	1092	928	1053
2008	873	1089	919	1058

Table 4 shows the mean differences or gap for SAT scores between the various school district categories. All of the means were significant at the 0.05 level. The result shows a widening of the SAT gap between urban impoverished and affluent school districts increasing from-223.25 in 1997 to -238 in 2000. The gap narrowed slightly starting in 2001 and maintained a positive trend except for 2005 when it slipped -.335% and 2006 when it fell -2.57%. The overall trend was positive culminating in a +3.47% in 2008 when compared to the 1997 SAT gap. Unlike the urban impoverished and affluent school districts, the gap between impoverished and non-impoverished school districts never improved or exceeded the 1997 SAT gap. The mean average SAT score for the urban impoverished school districts was at a 12-year high in 2008 (+1.041%) and the gap between affluent school districts was at a 12-year low (+3.47) using 1997 as the baseline year. A summary of the significant gains and losses is shown in Table 5.

Table 4. ***ANOVA Post Hoc Mean Differences 1997-2008 SAT Scores***

	Urb/Affl	SAT Gap since'97	Imp/ Non-Imp	SAT Gap since'97
'97	-223.25	0	-111.791	0
'98	-229.75	-6.5	-117.047	-5.256
'99	-230	-6.75	-127.488	-15.697
'00	-238	-14.75	-120.558	-8.767
'01	-218	+5.25	-143.05	-31.259
'02	-219.75	+3.5	-136.14	-24.349
'03	-218.5	+4.75	-153.79	-41.999
'04	-221.75	+1.5	-131.628	-19.837
'05	-224	-.75	-132.93	-21.139
'06	-228	-5.75	-126.047	-14.256
'07	-222.75	+.5	-124.721	-12.93
'08	-215.5	+7.75	-138.488	-26.697

Table 5. ***E-Rate Funding 1997-2008***

	Urban Impov	Affluent	Impoverished	Non Impov
E-Rate98	$18,910,561.75	$135,756.00	$1,020,603.49	$83,670.21
E-Rate99	$39,001,565.00	$94,840.00	$1,208,115.49	$106,529.88
E-Rate00	$27,773,048.00	$130,202.75	$1,400,259.95	$63,264.44
E-Rate01	$47,077,809.00	$155,204.50	$1,527,777.00	$78,572.35
E-Rate02	$37,633,302.00	$134,926.75	$1,149,118.88	$81,423.60
E-Rate03	$60,055,459.75	$136,970.00	$1,172,323.70	$91,208.98
E-Rate04	$37,342,813.00	$148,587.50	$1,071,467.47	$96,026.72
E-Rate05	$37,230,749.50	$150,369.50	$1,135,617.37	$127,606.30
E-Rate06	$30,365,988.75	$212,318.25	$902,440.93	$139,960.37
E-Rate07	$49,261,999.00	$202,213.50	$978,334.14	$135,579.05
E-Rate08	$31,689,157.25	$193,258.50	$943,463.33	$164,020.51

Figure 2 graphically shows the SAT achievement for all of the categories. The changes are hard to discern because they are small. SAT scores in general have remained flat for all school district categories.

Figure 2. SAT achievement gap 1997-2008

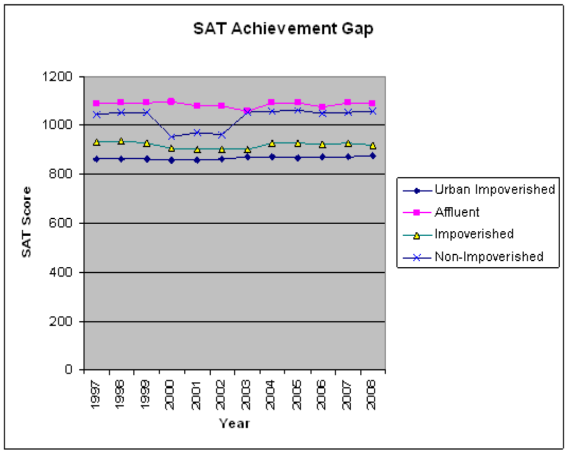
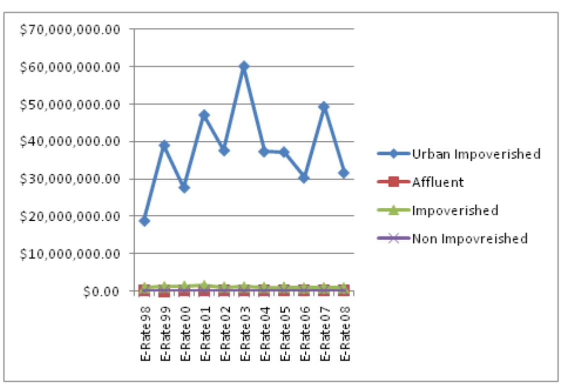


Table 5 summarizes the average funding for the various categories of school districts and Figure 3 graphically illustrates this funding level. E-Rate funding to urban impoverished school districts peaked in 2003. The graph shows the stark differences between the urban impoverished school districts and the other categories which varied from 18 to over 30 times more than the other categories combined. See Table 5.

There were no significant changes in dropout rate for urban impoverished school districts to merit the increase in SAT scores. An examination of the mean in Table 6 for dropout rate between 1997 and 2008 revealed that dropout rate had worsened from 1997.

Figure 3. E-Rate funding by school district category



Since dropout rate was negatively correlated with higher SAT scores, it would be expected there would be a drop rather than an increase in SAT scores. Table 6 conveys this information. The conclusion is dropout rate was not a factor in the SAT increase. The other factors such as student to teacher ratio and number of students testing were insignificant statistically according to the ANOVA analysis.

Table 6. Dropout Rate (%)

	Urban Imp	Aff	Impov	Non-Imp
Drop97	9.83	4.2	8.01	2.90
Drop98	16.72	4.8	10.59	4.04
Drop99	16.65	2.38	9.43	3.04
Drop00	15.1	2.02	8.61	3.08
Drop01	14.35	1.95	9.3	2.46
Drop02	15.77	1.5	8.08	3.88
Drop03	16.82	1.55	8.73	3.24
Drop04	13.22	1.4	8.92	3.58
Drop05	13.56	1.58	10.56	3.32
Drop06	15.12	1.72	14.05	5.96
Drop07	13.7	1.78	15.01	4.35
Drop08	15.8	1.6	15.27	4.82

11. SUMMARY OF FINDINGS

The hypothesis that increased funding had no impact on student achievement is not supported by the data because of the increase in SAT scores from 2003 (+.69%) to 2008 (+1.041%) when compared to 1997. Increased funding most likely accounted for SAT improvements from 2003 to 2008 for urban impoverished school districts because similar gains were not evident in the other school district categories except the non-impoverished category. Affluent school district SAT scores climbed +.183% in 2003 and remained steady at +.183% in 2008 when compared to 1997 SAT scores. Impoverished school districts fell by -.3.43% in 2003 and -1.39% in 2008 in comparison to 1997. The non-impoverished school districts showed a rise in 2003 of +.96% and rise of 1.34% in 2008. Non-impoverished school districts without massive E-Rate funding showed a steady decline from 1997 SAT scores. There appears to be an impact from E-Rate funding but it was small and almost imperceptible for urban impoverished school districts. In any case, SAT scores for the urban impoverished school district category were at a 12-year high in 2008.

Hypothesis 2 that the E-Rate program has not narrowed the student achievement gap between poor and affluent schools as measured on nation-wide assessment tests is not supported by the data. The achievement or SAT gap began narrowing in 2001 (+2.35%) and continued to make progress to 2008 (+3.47%) between urban impoverished and affluent school districts. There was no mirrored or similar improvement in impoverished versus non-impoverished school districts when compared to SAT 1997 scores. The gap between these categories fluctuated between -4.4% and -26.6% below the 1997 baseline. E-Rate funding may not have had a great effect on the achievement gap but it may have been enough to slightly improve and prevent further degradation of SAT scores and deterioration of the student achievement gap for urban impoverished school districts. In any case, the gap was at a 12-year low between urban impoverished and affluent school districts in 2008 indicating noteworthy progress.

12. DISCUSSION OF RESULTS

The purpose of this study was to examine the effect of E-Rate and its impact on student achievement. Student achievement was defined as scores on the SAT and ACT. The E-Rate is a program that funds IT infrastructure projects such as the Internet and network wiring for schools. Variables for the study included SAT scores, student-to-teacher-ratio, number of students testing, dropout rate, and E-Rate funding. Education data was gathered primarily from state educational databases and the National Center for Education Statistics. E-Rate data was assembled from the FCC's Schools and Libraries Division (SLD). The SLD is charged with administering the E-Rate program. There was a total of 94 geographically separated school districts in the study representing 801 high schools categorized into urban impoverished, affluent, impoverished, and non-impoverished. The urban impoverished school districts included Los Angeles Unified, Chicago Public Schools, Houston Independent School District, and the School District of Philadelphia. The urban impoverished school districts had a free and reduced eligibility population greater than 80%. The affluent schools districts included four school districts with free and reduced eligibility population of less than 15%. The impoverished school districts included 43 school districts collocated (same county) with the urban impoverished school districts with a free and reduced eligibility population greater than 50%. The non-impoverished school districts included 43 school districts collocated with the urban impoverished school districts with a free and reduced lunch eligibility population of less than 50%. Data collected covered a 12-year period from 1997 to 2008. The following questions motivated the study:

1. What has been the impact of the E-Rate program that has funneled over $18 billion dollars in IT infrastructure (Arfstrom & Sechler, 2006) for impoverished urban school districts on student achievement in secondary schools as measured on nation-wide assessment tests such as the Scholastic Aptitude Test (SAT) and American College Test (ACT)?
2. To what extent has the E-Rate narrowed the student achievement gap between poor and affluent schools as measured on nation-wide assessment tests such as the SAT and ACT?

In response to the first question, there has been progress on SAT scores in the post E-Rate period. If the 1997 baseline year is used, then progress started in 2003 when SAT scores exceeded the 1997 level. There was improvement in the urban impoverished school districts versus the affluent and impoverished school district categories. The SAT scores for urban impoverished increased from +.69% in 2003 to +1.042 in 2008 when compared to 1997. The SAT scores for urban impoverished school districts were at a 12-year high in 2008. No comparable increase in SAT scores was evident in the other categories except for the non-impoverished school district category. Affluent school district SAT scores climbed +.183% in 2003 and remained stable at +.183% in 2008 when compared to 1997 SAT scores. Impoverished school districts declined by -.3.43% in 2003 and -1.39% in 2008 in comparison to 1997. The non-impoverished school districts showed a rise in 2003 of +.96% and rise of 1.34% in 2008. In response to the second question, there was a narrowing of the achievement gap between poor (urban impoverished) and affluent school districts between 2001 and 2008 except for slippages in 2005 and 2006. The urban impoverished districts reduced the gap between affluent school districts by 2.35% in 2001 and 3.47% in 2008 using 1997 as the baseline year. The achievement gap between urban impoverished and affluent school districts was at a 12-year low in 2008. There was no similar narrowing of the student achievement gap between the other categories. The gap between impoverished and non-impoverished never declined from the 1997 level. The gap has fluctuated between -4.4% and -26.6% below the 1997 baseline.

13. CONCLUSIONS

The results of the study are in contrast to research results by Cuban, Kirkpatrick, and Peck (2001) and Wenglinsky (2005) that showed technology in schools does not improve student achievement. Ward (2005) who studied the impact of the E-Rate in Texas from 1994 to 2003 noted no improvement in SAT scores. Goolsbee and Guryan (2006) also studied effects of the E-Rate program from 1996 to 2001 in California and found no impact. This study contradicts Ward's and Goolsbee and Guryan's findings since improvement albeit small was observed starting in 2003. The methodology used in this study most likely accounted for this disparity. The school districts in this study were segmented and categorized therefore there was greater focus on the urban impoverished school districts. If school districts are not categorized as in this study then changes in SAT scores could be masked by the total numbers.

E-Rate is an IT specific initiative that had as its goal to narrow the achievement gap and it has achieved this goal in a limited fashion. The pre-E-Rate period (1997-2000) was a time period of slipping SAT scores (-.92%) and widening of the achievement gap (-6.6%) between urban impoverished and affluent school districts. The post E-Rate era (2001-2008) exhibited a reversal of the trends initiated in the pre-E-Rate period. The achievement gap narrowed between urban impoverished and affluent school districts by +3.47% between 1997 and 2008. In contrast, the gap between impoverished and non-impoverished school districts increased by -23.88% between 1997 and 2008. The results in this study support the contention that there has been some IT diffusion into the aforementioned urban impoverished school districts. Perhaps the gap between urban impoverished and affluent school districts would have been less positive without the impact of the E-Rate program.

14. RESEARCH CONTRIBUTIONS

With the exception of the studies by Ward, Goolsbee and Guryan, and Imazeki and Reschovsky, there are very few known studies that have attempted to quantify the effect of the E-Rate program on student achievement through empirical research. There has been a lack of credible measurement factors of the success of the E-Rate program as critiqued by the GAO. Nevertheless, billions of federal monies are funneled to poverty stricken urban school districts for IT infrastructure each year with the inferred hope that these funds spur student achievement (Arfstrom & Sechler, 2006). This study addressed the linkage between funding levels and student achievement. In addition, results of research on IT diffusion in education have been inconclusive where Chin and Marcolin (2001) stated that success measures linked to diffusion should be addressed and Schrum (2005) strongly argued that there was little documented systematic increase in student achievement linked to technological innovation and called for research in this area. Wan et al. (2007) concluded information technology was an important part in diverse learning environments but there was a particular need to examine the IT infrastructure and its effect in the learning environment

This research added information to the debate on whether there is a correlation between IT diffusion and student achievement by addressing some of the recommendations of past researchers (Chin & Marcolin, 2001; Schrum, 2005; Wan et al., 2007). These results provide important results to the FCC and other federal agencies that allocate monies to schools, specifically the E-Rate program in assessing effectiveness of these programs. GAO reports reveal a lack of accountability in this area. This study provided an initial baseline for assessing the effectiveness of the E-Rate Program. The study also showed a narrowing of the digital divide resulting from the E-Rate program.

15. POTENTIAL BIASES

There are several potential biases in the study from a methodological perspective. One potential bias is the selection of the urban areas for the study may not be representative of other urban areas that receive E-Rate funding in spite of the geographical dispersion. A second potential bias is the selection of the ACT and SAT may not be the best parameters to measure student achievement across various school districts. The third bias is there is an assumption that there has been some degree of integration of IT diffusion into the curricula based on the high level of targeted funding. There are also potential biases inherent in diffusion of innovations theory as outlined by Rogers (2003). The first implied assumption is a pro-innovation bias where the innovation or new idea is positive and will be readily adopted by users. Another bias from diffusion theory as articulated by McMaster and Wastell is the delineation of laggards from innovators is an arbitrary concept and not completely supported in empirical research. The researchers also contest the opinion that the majority of adopters are imitators. The researchers insist diffusion studies have been slanted toward innovation successes rather than failures.

16. RECOMMENDATIONS FOR FUTURE RESEARCH

The study needs expansion to include the impact of E-Rate on SAT scores for the top 50 urban school districts versus the four in this study to determine if the results from this study would be supported. A possible road block for a broader study would be obtaining permission to use the performance data since some states treat SAT scores and school district data as confidential data. Another potential research topic could be an in-depth analysis of the impoverished urban school districts between 2001 and 2007 to pinpoint what had been implemented to improve student achievement. This would involve surveys of the urban impoverished school districts to determine things such as what IT technology was established and how the technology was used in the curriculum.

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Is there a Student 'Disconnect?' First-year Hybrid Class Teachers' Observations and Recommendations for Improving Student Engagement in Information Systems Classes

Joan B. Parris
jbparris@una.edu
Computer Information Systems Department

Jana P. Beaver
jbeaver@una.edu
Management and Marketing Department

David W. Nickels
dwnickels@una.edu
Computer Information Systems Department

John D. Crabtree
jcrabtree@una.edu
Computer Information Systems Department

University of North Alabama
Florence, AL 35632-0001 United States

Abstract

Research shows that during times of economic downturn in the United States, education funding suffers. One method that higher education administrators are choosing to ease the economic crunch is to offer hybrid classes that blend one regular face-to-face class meeting with online and outside class components. The challenge of managing large numbers of students in hybrid classes while fostering student engagement can be monumental for higher education teachers. This article presents a discussion of observations and recommendations from the writers' experiences as first-year hybrid class teachers within an information systems environment.

Keywords: hybrid classes, blended classes, student engagement, information systems education, team projects, Web facilitated courses, distance learning

1. INTRODUCTION

Many higher education institutions are experiencing tough economic times during the current downswing in the economy (Johnson & DeVise, 2010; Laster, 2010). Not surprisingly, existing research suggests that state appropriations to higher education in the United States are negatively impacted by downturns in the economy (Humphreys, 2000; Betts & McFarland, 1995; Russell, 2008). Some institutions are trying a variety of creative ways to extend student coverage by existing faculty in order to stay within tight budgets, especially in states that have had to issue proration to education budgets. One of the methods being used is the hybrid class format, which is also referred to as blended learning or a blended learning environment (Osguthorpe & Graham, 2003). These authors believe that there is probably no magic "fix" for these budget constraints and that hybrid classes are likely to continue to grow as a percentage of all higher education course formats.

In this article, the authors discuss the existing literature on hybrid classes, provide observations from their collective experience as first year teachers of hybrid classes, present the major problems with student engagement that have been encountered in these classes, offer teaching tips for dealing proactively with those problems, and detail a planned action research project to promote higher levels of student engagement in hybrid classes.

2. LITERATURE REVIEW

Higher education continues to expand use of online learning and blended learning courses. In the Sloan Consortium's annual reports concerning online education, their 2007 iteration (Allen, Seaman, & Garrett, 2007), the first to have sufficient data to report on hybrid, or blended learning, was based on three years of survey results from over 1000 colleges. This study categorized the types of learning based on the amount of content placed online in the following way: 0-29% face-to-face, 30-79% blended/hybrid, and 80+% online. Generally, 1-29% might be web-facilitated, which utilizes a learning management system or the use of a website to upload a syllabus and assignments to assist in the face-to-face course, while the 0% is considered truly traditional with only oral or written content from the instructor. In the blended or hybrid category, instructors 'blend' by delivering content in a classroom setting and also provide a substantial amount of content in an online format, normally reducing the face-to-face class meetings from a traditionally met course. For the online description, most or all content is delivered online. In the 2007 Sloan report, 55% of all colleges offered at least one blended course, and 64% provided at least one online course, with business programs offering a higher percentage of blended (47.9%) and online (42.7%) offerings than other academic areas. The answer to one of the key questions in this research, "Do blended courses hold more promise than fully online?," was that academic leaders rated them fairly equally (Allen, Seaman, & Garrett, 2007). In relation to student preferences for different class formats, the Allen, Seaman, & Garrett (2007) report showed that of over 2,000 adults surveyed about their first preference for course deliver mode, the preferences expressed were mixed:

- 24% preferred a web-facilitated course/program that was primarily on-campus,
- 22% wanted a course/program that was fully on campus,
- 20% preferred totally online courses/programs,
- 19% preferred primarily online blended courses/programs,
- 14% wanted equally distributed offerings of blended, online, and face-to-face courses/programs, and
- 2% preferred other distance learning programs, such as video and audio.

Interestingly, the percentages reported by the respondents as to the likelihood of taking these types of courses, however, were higher than those of their respective preferences. The authors concluded that the results suggested that even though there is a growing acceptance of online delivery methods, there is still some comfort in campus-based instruction.

A natural question that arises from a consideration of these different course formats is how student interaction with class activities may be differentially impacted among those formats. A literature review indicates that, at least on a preliminary basis, that there may indeed be differential impacts in different formats on student interaction with course activities.

Kozak (2009) collected data from four sections of the same course: a 15-week face-to-face section, a 15-week blended section, an 8-week blended section, and an 8-week online section. In a self-assessment in which students were asked how many hours per week outside of class they spent on the course, the students reported spending averages of 9.21 hours per week in the face-to-face format, 10 hours per week in the online format, and 8.31 hours per week in the blended format. These averages reflected an addition of three hours per week for the traditional and hybrid in-class sessions. While this study's main focus was online students' learning, for our purposes it is interesting to note that the students in the hybrid section spent the least amount of time on the course. In relation to their categorical satisfaction with the instructor's conveyance of the material in an interesting way, the challenge offered by the course, and the amount of learning that resulted from the course, the students reporting the highest satisfaction levels were in the online course, and the face-to-face students' means were slightly lower in each category than the hybrid students' numbers. In Yudko, Hirokawa, and Chi's (2008) study of students in a small, rural university, students reported a belief that the hybrid format negatively affects class attendance, although they did not self report decreased attendance in hybrid classes.

3. OBSERVATIONS FROM FIRST-YEAR HYBRID TEACHERS

This article is based on the experiences of first-year hybrid teachers in information systems courses at a regional university. Collectively, these experiences have suggested that (1) there is a student engagement problem in hybrid classes, and (2) the engagement problem leads to decreased chances of success in the course both in grades and learning outcomes.

Discussion of the most consistent problems observed in hybrid classes will follow, but to provide context, a description of the hybrid format within this regional university setting follows. The information systems courses studied for this article were both sophomore-level courses: "Introduction to Programming" and "Information Systems in Organizations." The programming course is a required course in the information systems major in a college of business. The information systems course is a required course for all business majors at the university. These two courses were not pre-advertised in scheduling materials as hybrid (meeting only one day a week). When students registered for the course, they were committing to a two-day-a-week class meeting schedule. With surging enrollments in both of these courses, the enrollment maximum cap was extended by the administration to allow both courses to grow and convert to hybrid classes. It is also relevant for our discussion to add that both of these courses were taught in lecture rooms with only 25 computers. Therefore, at the first class meeting of the semester, the classes were divided in half and for the rest of the semester one half met on the first class meeting of the week (Mondays for Monday-Wednesday classes or Tuesdays for Tuesday-Thursday classes) and the other half met on the second class meeting day (either Wednesday or Thursday).

Inconsistent Student Engagement

These authors have noticed a difference between the levels of student engagement within the hybrid classes as compared with the student engagement in traditional face-to-face classes or totally online classes. The hybrid students do not seem to have an understanding of what a hybrid class is other than telling their friends, "I only have to attend class one day a week!" The hybrid section's students in general do not seem to understand that they need to be engaged in course activities at other times of the week in addition to just that one class meeting.

Peer evaluation results from teamwork projects in the hybrid classes also indicate this inconsistency in student engagement. Too often, comments similar to the following have appeared on these evaluations from students in the hybrid classes: "She did not make any effort to contribute to the project until the night before the presentation, and the rest of us had it all finished by then" or "He did not show up at any of our group meetings and never told us why he was not there—and we met MANY times."

Another clear indication that students in hybrid classes often are not consistently engaged in course activities at days other than the one class meeting day can be seen in the charts in Figures 1 through 4. These charts have been extracted from the online Angel Learning course management software for one of the hybrid classes studied. It is important to note that all of the "out of class" activities for the course shown in these figures had required information posted in the course site within Angel Learning. There were also PowerPoint slides posted for student reinforcement of the class lectures. Also, three team projects utilizing decision support software required students to access data files and post comments on the teams' private discussion boards. Teams were required to have evidence of teamwork and team files posted in their discussion boards. All assignments were to be turned in by submitting through the online assignment drop boxes within the Angel Learning course site. So, there was a consistent need throughout the semester (and not just on the one class meeting day) for the students in the class to access the Angel Learning course site and respond to team members' discussions, access reinforcement materials, access data files needed for the projects, read and respond to e-mails from their teammates and teacher, and take care of other course business.

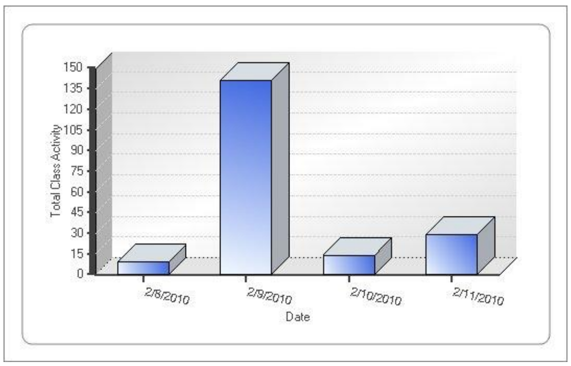

Figure 1. Total Tuesday Class Students' Activity During a School Week in the First Month of the Semester

The above chart shows the total activity for all students in the Tuesday hybrid class for the Monday through Friday activity log. This activity log still indicates that students in the class as a whole had little or no activity on days other than the Tuesday class meeting day during the first month of the semester. There was no activity on the Friday of this week.

Figures 1 through 4 reflect the following context: Monday through Friday activity logs from weeks in the first and last months of the semester within the course homepage in Angel Learning course management system, a hybrid class meeting one day a week, course requirements involving work on cases, teamwork projects, chapter journals, discussion activities, and other assignments to work on outside of class, and most activities requiring access to the course homepages.

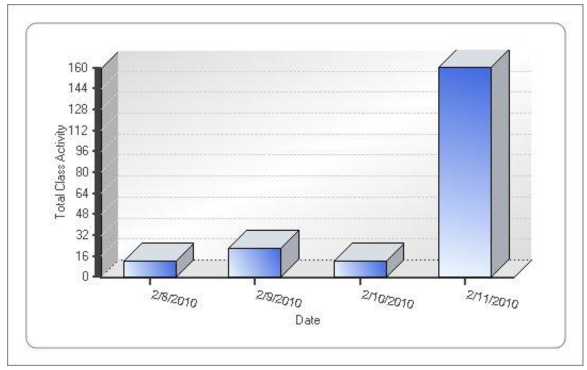

Figure 2. Total Thursday Class Students' Activity During a School Week in the First Month of the Semester

The above chart shows the total activity for all students in the Thursday hybrid class for the Monday through Friday activity log. This activity log still indicates that students in the class had little or no activity on days other than the Thursday class meeting day during the first month of the semester. There was no activity on the Friday of this week.

There is some evidence in the class activity data shown in Figures 3 and 4 (data from a week in the last month of the semester) that as the semester progressed, the student engagement in the course improved. The total class activity reports from both a Tuesday and a Thursday class meeting in a hybrid class indicate this improvement. This increase in activity is also often observed in traditional classes and online classes as students become more concerned about their final course grade during the last month of the semester. However, since there appears to be a sizeable increase in activity on all days of the week (except Friday), it is possible that students have finally at this point in the semester become aware that they need to be engaged in the course more during the entire school week and not just on the one class meeting day. This observation of increased student activity during the last month of the semester caused the authors to formulate a plan for a future study proposing a formal hybrid class training session in the first days of the semester to show students how to stay actively engaged in the course in order to improve their chances for higher achievement of learning outcomes and higher grades. This plan is discussed later in this paper.

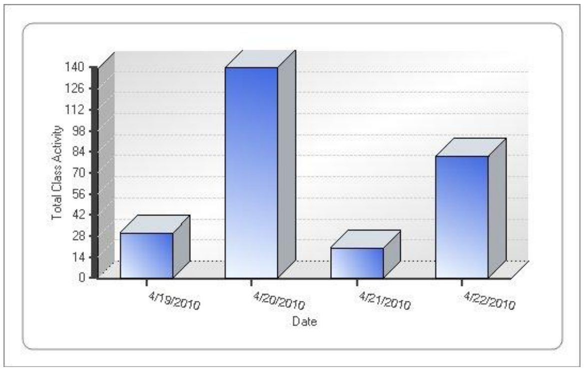

Figure 3. Total Tuesday Students' Activity During a School Week in the Last Month of the Semester

The above chart shows the total activity for all students in the Tuesday hybrid class for the Monday through Friday activity log. This activity log indicates that students in the class had an increase in activity on days other than the Tuesday class meeting day during the last month of the semester. There was no activity on the Friday of this week.

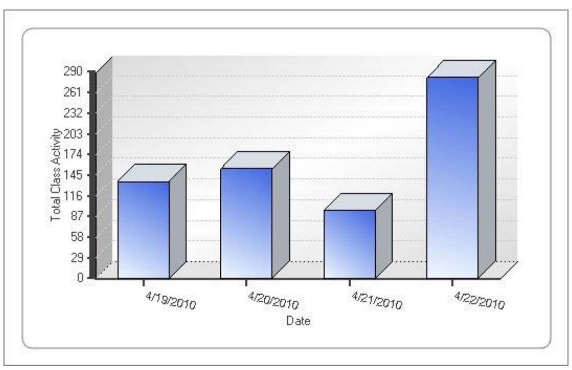

Figure 4. Total Thursday Students' Activity During a Week in the Last Month of the Semester

The above chart shows the total activity for all students in the Thursday hybrid class for the Monday through Friday activity log. This activity log indicates that students in the class had an increase in activity on days other than the Thursday class meeting day during the last month of the semester. There was no activity on the Friday of this week.

One unique fact that emerged when studying the class activity reports is that the hybrid students may not access the course's online materials or discussion boards at all on Fridays: the students seem to take Friday off from hybrid classes. This fact is consistently demonstrated in each chart shown in Figures 1 through 4. There is no course activity data on Fridays for any of the 45 students in the two weeks shown.

4. STUDENT PERFORMANCE PROBLEMS IN HYBRID-FORMAT COURSES

These authors believe that the student engagement deficiencies detailed in the previous section lead to a number of student performance deficiencies in hybrid-format classes. Those deficiencies are detailed in the following observations.

Problem: Student Reading and Comprehension Issues

One of the problems observed in the hybrid classes is also a problem that teachers of regular face-to-face and totally online classes have observed: students do not read assignment instructions, or they do not comprehend the instructions that they do read. Too often, students will ask questions before, during, or after class about an assignment details, an assignment due date, a test date, etc. when the answer to their questions are clearly posted in the online materials at the Angel Learning course site. Also, when students ask questions for which answers have clearly been posted in the online materials since the beginning of the semester, it is obvious that they have not even seen or they have not comprehended the material that has been posted for them. This problem may be magnified in a hybrid class because more information and details are posted in the online course materials and less time is available in the one weekly class meeting to discuss details in depth. These observations suggest that hybrid class students must learn to rely more on reading online material rather than being "spoon fed" every detail by the teacher during class.

Problem: Student Attendance Issues

The collective observation of these teachers is that the student absenteeism rate is higher in the hybrid classes studied than in regular face-to-face classes. This is a critical point because missing one hybrid class day is the equivalent of missing a week of regular face-to-face classes. It is possible that students feel more anonymous in hybrid classes because of just meeting class one day a week. A unique hybrid class observation that was not often seen in traditional face-to-face classes in this particular college at this regional university is the fact that there were a small number of students who were non-participants in the team projects. For example, in one hybrid class where each of the three team projects counted 10% of the final course grade, a student came in on the last team project presentation day and told the teacher, "I had no idea we were doing another team project." The team discussion board was clearly visible in each team member's assignment folder in the online materials. The student had been assigned to the team within the Angel Learning course site, and the procedure was no different than the two team projects that had been completed earlier in the semester. The last team project was clearly announced in the course calendar that was attached to the course syllabus that this student had received at the beginning of the semester. The total disconnect exhibited by this student ties back to the lack of consistent student engagement issue discussed earlier. All of the first-year hybrid teachers involved in the study have experienced similar student absenteeism and student disconnect issues and believe that they have had more of these issues in the hybrid class format than in the traditional face-to-face or totally online classes.

Problem: Students' Failure to Submit Assignments

There have been more observed instances of students failing to submit assignments by established due dates among the hybrid students than these writers have observed in traditional face-to-face and totally online classes. There have also been students who just did not turn in case studies or other assignments and received zeros for the missed assignments. This issue has not occurred very often for the writers of this paper in the traditional or totally online classes. This issue can probably be tied back to all of the previously mentioned observations: the inconsistent student engagement issue, the student non-reading issue, and the student absentee issue.

5. RECOMMENDATIONS FOR IMPROVING STUDENT ENGAGEMENT IN HYBRID-CLASSES

These authors have collaborated on potential proactive strategies to address student performance deficiencies in hybrid format classes. These strategies are presented and explained in the following tips.

Tip: Plan, Plan, Plan!

Perhaps the best tip for improving student engagement in hybrid classes is for the teacher to plan like he or she has never planned for a class before. Every detail of both the in-class activities and the online and out-of-class activities needs careful thought and attention as to how it will be handled in the hybrid class format. Practically everything that the instructor discusses, explains, or mentions in class needs to also have an online presence in the course management system. Detailed assignment directions, detailed grading rubrics, or assignment expectations need to be carefully organized and posted online for the students.

Tip: Set Expectations Early, Clearly, and Consistently

A carefully planned syllabus, a semester-long calendar, and assignment drop boxes should be posted in the online course management system by the first day of classes so that the students know at the beginning what is expected of them and when the assignments are due. The specific details on the topics involved in case studies or the specific project topics that will be assigned do not have to be made available on that first day of the semester, but the students need to know that they will have these assignments and they need to have an idea of what is due when. Giving the students some of the details of these cases and projects will help students in budgeting their time for the semester. Setting consistent due dates on a weekly basis is another way to help students stay focused and engaged. In one of the hybrid class clusters (a Tuesday hybrid of 22 students and a Thursday hybrid of 23 students), all assignments were due on Sunday nights at midnight. That seemed to eliminate questions about specific due dates. If the fact that a certain assignment was due "this week" was mentioned in class, in an e-mail, or in an online announcement, the students knew it was due Sunday night at midnight. By having both of the hybrid sections assignments due at the same time, this also helped the teacher to easily keep the due dates straight.

Tip: Convey the "Big Picture"

The careful planning and organization before the semester begins should help students to see the "big picture" for the class for the semester and help them to realize that it cannot all be accomplished during the one class meeting per week. For those students who work, those who have families with children, and those who are taking heavy course loads during the semester, the carefully planned course calendar and details will be crucial for their success.

Tip: Use Team Projects to Promote Continuing Engagement

Utilizing team projects and changing the team members for each new project during the semester adds to the level of student engagement in hybrid classes. If students are in the same team for the entire semester, they may become bored or complacent. The writers of this article used three team projects in the "Information Systems in Organizations" class, and the team members were totally changed each time. An advantage of changing the team memberships for each project is that it gives the student the potential be in various roles in different teams. On one team, the student may end up being the unofficial team leader. In another team, the student may be the technology leader for that team. Or, the student could move to the role of follower in another team and still contribute heavily to the team's work.

Tip: Keep Communications Simple and Clear

There was discussion earlier in this article about how today's students do not always read carefully and do not always comprehend what they read. One way to assist the students with this issue is to avoid whenever possible very long assignment details or e-mails. It has been observed that students who read long e-mails with three main points or topics often ignore or do not notice one or more of those topics. These writers have seen more success when sending three short e-mails on three different topics (assignment detail, testing information, etc.) rather than sending one long e-mail that covers all three topics. This communication disconnect may not be that much worse with hybrid students, but teachers of hybrid classes do not have as much class time to spend in making sure the students comprehended the communication as they have in a traditional face-to-face class.

Tip: Use Technology to Promote Out-of-Class Engagement

Invariably, some students will have personal emergencies that result in absences on the one day that the hybrid class meets. To assist the absent students in making up the missed class, utilizing a video capturing software tool, such as Tegrity, to record class lectures is beneficial. This video capture tool has been used quite successfully in many hybrid classes at the authors' university, but it may have been most effective in the programming course in the information systems major. When students who are not as adept in developing initial programming skills as others have to miss a lecture, there is much to overcome. If that student can enter the online course site within the course management program and watch the video, or at least watch crucial video segments of the missed lecture, then this student has the same opportunity for class success as those students who were able to attend the class.

While the authors' university campus has adopted the use of Tegrity software to record video/audio/screen capture, there are other options for recording instructor lectures, workshops, and tutorials for use within learning management systems. One of the authors uses Camtasia Studio (http://www.techsmith.com/camtasia.asp). Another solution for very short clips, less than 5 minutes, is a free program (not a trial) called Jing. For those professors who need longer videos, the expanded Jing Pro version can be purchased for a very reasonable price per year.

The addition of software to record video, audio, and screen capture can be quite expensive for higher education campuses. The authors' university campus spent approximately $70,000 ($60,000 in licensing and an additional $10,000 for servers and webcams) for the Tegrity software integration with the Angel Learning management system. The cost for this software integration was about $10 per student for this university's approximately 7,000 students. Echo360 is another video capture software that has pricing similar to Tegrity's price. Camtasia Relay is considerably less expensive and runs about $10,000 for the license and an additional $10,000+ for the server hardware. There are several other brand names available on the market for video capture software.

Recording the classroom lectures to upload to the course management site does more than assist the students who must be absent from class. The recordings serve as reinforcement to the lectures because students may watch again the part of the lecture that they did not totally understand during their one day of class with the teacher. The videos also serve as good review material for tests. So, in addition to helping with overcoming class absence issues, the videos also assist with the student engagement and with the issue related to reading and comprehension. The students may gain more from watching the lecture over and over again than they would by trying to read and comprehend the material in the textbook by themselves.

Traditionally, there are usually issues surrounding the video technology that can be difficult for the teachers and students in hybrid classes to resolve. Sometimes the recordings do not work properly during class and have to be re-recorded by the teachers after class in their offices. One teacher has decided that overall, it works best to make several small videos during the lecture on different concepts as opposed to a single video over an hour in length. This teacher also recommends that to work effectively with blending the video, the PowerPoint slides, and textbook content into the lecture video clips he plans to use an electronic version of the textbook in the future.

Students who live on campus generally have access to strong technology support for their online and hybrid classes. Sometimes, students who live off campus have inferior Internet service to their fellow students on campus and can experience technology issues. Students who have broadband Internet access generally do not have a problem viewing the lectures. Those with dial-up or sub-optimal connectivity (e.g., ISDN) have great difficulty watching the videos in a streaming mode. For those students, it is possible to make a download link available which will download the entire video to the local drive and enable them to play the video "offline." Some students have problems playing videos that are "embedded" within a CMS-managed browser window. Within the Angel Learning course site, it is possible to make the link appear in a new window without a border.

6. METHODOLOGY FOR ADDITIONAL RESEARCH: A POTENTIAL STRATEGY FOR IMPROVING STUDENT SUCCESS IN A HYBRID CLASS

Based on this writing team's observations of problems with student engagement in hybrid classes and especially after reviewing the student activity reports within the hybrid classes' Angel Learning course management system (described in the charts in Figures 1 through 4), the research team plans to conduct additional study during the next fall semester. The next stage of study will revolve around the writers' beliefs that a carefully planned, standardized, formal training with students is needed in the first day or two of the semester with a focus on correcting any misconceptions that they may have about hybrid classes and an emphasis on the need for continuing student engagement in the hybrid classes.

The writers are planning to produce a hybrid class performance skills video training segment that could be shown in all hybrid classes within one department on campus. A pretest survey covering attitudes about hybrid classes will be developed for the students to take prior to the training. The survey will have questions for students who have had prior hybrid class experience and for those who have not had prior experience. After going through the formal hybrid class training, the students will be given the same survey as a posttest to determine if the training accomplished the goal of changing misconceptions about hybrid classes (specifically, has the training helped change the student's perception of the level of student engagement or commitment needed for success in hybrid classes?). At the conclusion of the semester, the hybrid class students will be surveyed in an effort to gather their attitudes and beliefs about the hybrid class and how they felt about the design and implementation of the class. The writing team will continue to discuss their observations and monitor student activity within the online course sites throughout the semester and report their study results.

7. CONCLUSION

There is sufficient evidence from these writers' hybrid class experiences to indicate that there is potentially a natural student 'disconnect' in relation to student engagement in hybrid classes. This disconnect can be partially corrected by the teacher's careful pre-planning before the beginning of the semester in developing the online course environment and in planning meaningful out of class activities and projects. The writers also believe that there is strong potential for improving consistent student engagement in the hybrid classes with a short but formal "hybrid training session" during the first days of class to be certain that students understand the concept of hybrid classes and their need to be connected, engaged learners beyond the one day a week that they attend class. Additional research and pilot hybrid training sessions will be conducted by the writers during the next semester's hybrid classes and the results will be reported in a future article.

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A Model for Long Term Assessment of Computing and Information Systems Programs

Hisham Al-Mubaid
hisham@uhcl.edu

Dan J. Kim
kimdan@uhcl.edu

Kwok-Bun Yue
Yue@uhcl.edu

Sharon Hall
perkins@uhcl.edu

Krishani Abeysekera
Abeysekera@uhcl.edu

Division of Computing and Mathematics,
University of Houston – Clear Lake,
Houston, TX, 77058, USA

Abstract

Assessment practices and requirements are very broad and vary widely among academic programs and from one institution to the other. Consequently, we noticed, in the recent years, increased volumes of research and interest geared into the assessment process and procedures in various disciplines in higher education. In this paper, we present and explain a model for long term assessment and a set of robust tools and techniques within the framework of process steps, team work, and task-driven process management. Using this presented assessment methodology, we have been successful in our accreditation efforts, and improved the quality of our programs. This model can be used for long-term assessment with several years of task scheduling and assessment timeline. We share our views and thoughts in the form of lessons learned and best practices so as to streamline the process of assessment and simplify its procedures and steps.

Keywords: Assessment, Assessment model, Assessment tools, Information Systems programs, Accreditation

1. INTRODUCTION

Motivation: Assessment practices and requirements are very broad and can be interpreted and applied in many ways. In this work, the main motivation is to tackle an assessment process and present a well specified assessment model and set of tools with the framework of process steps, team work, and project based task. Moreover, this work can be viewed as a way to share and disseminate our work practices, findings, and lessons learned in an assessment task.

Background: For an educational accreditation purpose, a certain form of assessment is typically mandated by a national or regional accreditation agency such as ABET, AACSB, and SACS, with the main responsibility of maintaining the standards for degree confirmation. An assessment process can be viewed as a simple and direct evaluation of an academic program or discipline in an educational institution. Assessment can be accomplished at various levels. Typically three levels of assessment can be distinguished:

- Institution-level assessment,
- School-level assessment, e.g. school of business, or school of education
- Program-level assessment, e.g. information systems program or accounting program.

Program-level assessment is the focus of this paper.

Reasons for Assessment: Reasons for assessment can be grouped into three major categories: (1) to satisfy external accreditation requirements at various levels: university, school and program; (2) to satisfy internal requirements of the university, such as periodic program reviews, etc.; and (3) to utilize the results internally to improve the programs or for recruiting and marketing purposes.

Goals of This Paper: This paper presents and explains a set of robust and compressive assessment guidelines for computing and information systems fields. We designed and implemented a comprehensive assessment methodology for two computing programs. We started with the mission statement and streamlined the main objectives of the programs. The method includes a comprehensive and solid set of measurable goals and outcomes. The results of applying this assessment methodology are then taken into the last phase which is known as 'closing the loop'. In the closing the loop phase, we take the assessment results and apply the recommendations to improve the quality of the programs. We have been using this presented assessment methodology for several years and it has helped us to improve the quality of our programs. Moreover, this assessment method has helped and simplified the accreditation process of two computing programs by ABET under the IS and CS curriculum guidelines.

2. LITERATURE REVIEW

Faculty who recognize the advantages of an accredited program are familiar with curriculum models and accreditation requirements. Landry, et al. (2009; 2006) discuss the Information Systems (IS) 2002 model curriculum and how 150 learning units are mapped into 6 IS core areas. The model curriculum is a result of a collaborative effort that describes the characteristics of the IS profession.

Hilton, et al. (2003; 2004) conduct a comparison of the school-level Association to Advance Collegiate Schools of Business (AACSB) and program-level ABET/CAC accreditation standards. They find AACSB and ABET/CAC accreditation standards to be generally compatible. Based on a survey of IS program leaders in business schools, understanding of potential benefits of accreditation were quite low. Challa, et al. (2005) find that much of the requirements of ABET, including assessment, is applicable to IS programs.

Nicolai (2004) addresses the dilemma of how a particular curriculum is positioned into an accreditation model. She concludes that "IS expects database students to achieve a higher level of learning (application) and IT expects database students to achieve the first level of learning (understanding)."

Sun (2003) and Kortsarts et al. (2009) discuss the technical and personal skills that need to be mastered in order to be an effective IT person. Necessary skills include: helpdesk skills, programming and optimizing code, systems administration, security, systems integration, database, web mastering, knowledge of disaster recovery procedures, and business planning. Such a person would also possess personal skills: creativity to know whether a thing is possible, ways to work around problems, organization skills, interpersonal skills, the ability to explain complexities in simple terms, to link components together, to see where future growth can happen, to work effectively on a team, and the spirit and practice of cooperation. The assessment of such skill mastery is, thus, critical to an IT program.

3. A CONCEPTUAL MODEL OF ASSESSMENT

Adapting the basic components of assessment from the ABET Assessment for Quality Assurance

Model (ABET, 2010), we propose a conceptual model of assessment (see Figure 1), which could be used to prepare educational assessment in general. The conceptual model consists of three parts: institutional/school/program level's guidance components, evaluation components, and feedback. The guidance components are related to the direction of institutional/school/program, which include mission, objectives, and outcomes. A mission is a broad and long-term vision of an institution/school/program. There will be objectives, outcomes, and strategies used to achieve the mission, but the mission is the eminent and most important aim to be accomplished. Objectives, on the other hand, are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. Outcomes are statements that describe what students are expected to know and are able to do by the time of graduation (Vlasceanu, Grunberg, & Parlea, 2007). If students have achieved these outcomes, it is anticipated that they will be able to achieve the educational objectives after graduation. Appendix 1 shows an example of program level mission statement, educational objectives and outcomes. The evaluation components include performance measurement criteria of the guidance components, assessment of performance, and interpretation of the results of assessment. While the guidance components are about "where to go," the evaluation components are related to analysis mechanisms to answer "where do we stand."

Performance criteria are specific and measurable statements identifying the performance(s) required to meet outcomes (Prados, Peterson, & Lattuca, 2005).

These should be high level measurable statements that represent the knowledge, skills, attitudes or behavior students should be able to demonstrate by the time of graduation. Assessment is related to the processes that identify, collect, use and prepare data that can be used to directly or indirectly evaluate performance (i.e., achievement). Interpretation is the process that is used to interpret the meaning of the assessment results and provide recommendations. The feedback process is critical to creating and maintaining a systematic quality assurance system. When successfully implemented, all elements of the quality assurance process interact with one another (ABET, 2010). This model can easily be mapped to the assessment requirements of accreditation bodies such as ABET (2010), AACSB (2010), and SACS (2010), as well as the internal needs and framework for program improvement.

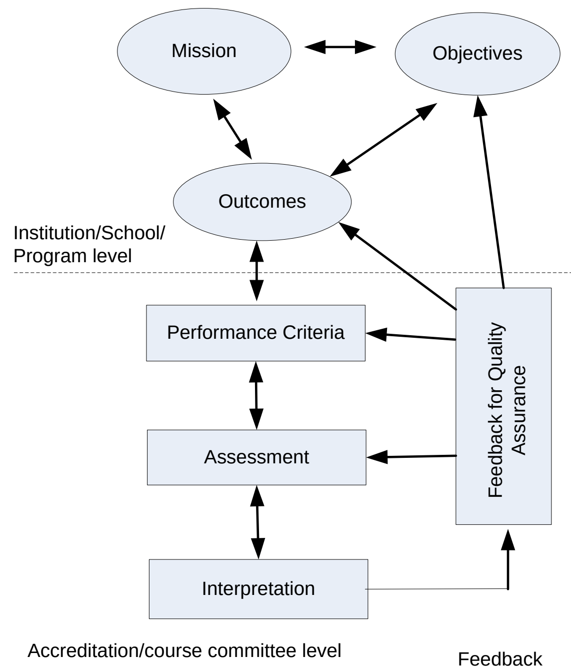

Figure 1: Conceptual Model of Assessment

4. ASSESSMENT MODEL IMPLEMENTATION

We followed this model to prepare for both ABET accreditation and internal program improvement. A committee of five dedicated faculty members were selected for the assessment committee. This committee met regularly to spearhead the assessment cycle.

Assessment Methods: The assessment committee identified several methods in which assessment of outcomes could be done. Some of the methods identified were indirect methods of assessment, while others were direct methods (see Appendix 2 for an example). Indirect methods were easy to implement and less time consuming. The best example of indirect methods is the exit student survey on how well they think course objectives are satisfied.

The results of these were not as convincing as they were more of an opinion rather than a fact. Nonetheless, they can be useful to effectively identify issues that need to be improved. Direct methods, on the other hand, were much more time consuming to the instructor; however these results were more relevant and accurate. The committee identified and adapted 11 assessment methods, out of which 9 were direct methods of assessment.

It was critical that the faculty did not get overloaded with assessment. Overloading the faculty would have been a recipe for failure. It was imperative that assessment methods were assigned evenly. Therefore, some of the direct methods were identified to be prepared and judged by the course instructor, while others were assigned to be evaluated by a committee of faculty members or the course committees and still others were assigned to be assessed by industrial advisors.

Mapping Courses to Outcomes: It is necessary to find out which courses would satisfy the different outcomes for each program objective. The course committees for each class identified course goals for each course, and with these course goals, the assessment committee identified which courses mapped to which outcomes (see Appendix 3).

Assessment Timeline: After learning outcomes and multiple assessment methods were decided, it was imperative that the assessment cycle was achievable, so that assessment did not fall through the cracks. It was the view of the committee that a good timeline that did not overly tax any one course or one person much would be a more practical assessment cycle. The timeline took into consideration each objective for the program. Every outcome in each objective was assessed once every 3 years. In this way, most classes were assessed once every 3 years, or every 2 years at most. This seemed like a very achievable plan with very minimum impact on workload, which is a common concern among faculty (Hogan, Harrison, & Schulze, 2002).

Closing the Loop: Assessment on its own would have no impact on the program. The resultant recommendations and outcomes from the assessment would eventually make for a better program. As feedback mechanisms of quality assurance, the recommendations that are applied to the assessment results not only improve the program, but also give us information about the quality of classes, the quality and ability of our students, and shows us where we have to improve.

In closing the loop, we realized that some classes were overloaded with material. In some instances, it was necessary to add more material into classes, while some classes required no changes. Other categories of recommendations we had implemented include changes in program and course outcomes, changes in performance criteria and assessment tools, increases in course support and changes in instructors.

5. DISCUSSION AND LESSONS LEARNED

In this section, we present a discussion of our views and thoughts on the assessment. We also discuss the lessons learned in this work. These views, thoughts and lessons learned are summarized in the form of three best practices as follows.

Best Practices: Formation of a program accreditation and assessment committee
In the past, our ABET accreditation effort was spearheaded by one or two individual faculty members, usually the program chairs. This resulted in uneven faculty participation and missed tasks. Despite best efforts and successful accreditations, the experience was less than fulfilling for all those involved. There was not sufficient discussion among faculty members to recommend and implement comprehensive changes to improve the programs. Efforts were focused only on issues of perceived weaknesses related to accreditation. Furthermore, the concentration of work created stress for the lead persons.

However, it is also not realistic to manage accreditation preparation through the entire faculty body. We tried to discuss nuanced accreditation issues during full faculty meetings in the past which usually ended inefficiently as faculty with different levels of understanding tended to over discuss unimportant issues and details. The uneven level of contributions during and after the meetings also discouraged faculty participation.

In the latest ABET accreditation cycle, we formed a committee of five devoted faculty members to lead the effort for both accreditation and assessment. This turned out to be a suitable size for gathering ideas and actually executing the preparation plan. Every member was active. As the committee successfully resolved tasks effectively, a culture of teamwork established. The resulting collaboration continued beyond accreditation and assessment, resulting in resolving other program matters and publications of papers. Merging the accreditation and the broader assessment efforts also reinforced each other.

Best Practices: Adoption of a management process for accreditation and assessment

Accreditation and assessment involve many concurrent tasks to prepare a large collection of documents. These tasks need to be identified, refined and specified. Solutions to these tasks need to be designed and implemented (Mayes & Bennett, 2005). Leaders and supporters of tasks and deadlines need to be established and followed through. Many documents need to evolve in time and may also have variations to satisfy different needs. Furthermore, documents are updated and accessed by many different groups of users: faculty members, supporting staff, adjunct faculty, course committees, etc. Thus, in a sense, accreditation and assessment can be regarded as a project with many similarities with software development projects: risk management, version control, feature completeness, etc.

As a result, an early task our accreditation committee undertook was to adopt a reasonable project management process. On one hand, we needed a process to ensure the systematic identification and completion of needed tasks. On the other hand, the process needed to be informal enough to let innovative ideas flow freely.

As information systems and computer science faculty members, we borrowed ideas from Rational Unified Process (RUP) (Kruchten, 2003) and Scrum Development (Wikipedia, 2010). RUP is a leading iterative software development framework and Scrum is "an iterative, incremental framework for project management and agile software development" (Wikipedia, 2010). Ideas we borrowed from them are iterations of task management until completion, frequent and systematic status updates, change control, continuous quality verification, and heightened communications through frequent meetings.

The process we eventually adopted was to hold weekly meetings. All documents developed during the week were captured in a dedicated work area folder which also serves as an archive and version control. A progress file, simply in Microsoft Word format, documents every task, its leader and steps remaining to be done for the task. The urgency and progress status of each task is color coded. Each task was re-visited each week to check its progress with possible re-examinations of their goals, design and implementations. This ensures that tasks are completed effectively within deadlines and that no task was missed. The longitudinal sequence of progress files also provides a good history of progress.

We were cautious to identify tasks that were best resolved during the meeting and they were worked upon immediately. For example, the assessment committee refined the wordings of updated program objectives during the meetings. This provided quick consensus so that the objectives could be presented to the full faculty body for approval rapidly. On the other hand, there were many tasks that could be accomplished individually after the meeting.

We would have used project management software which provides aids using a more formal project management process. However, since the key members met frequently in person, we found that our informal approach incurred the least overhead while keeping communications of ideas open.

Best Practices: Use of technology when appropriate

We used technology to aid the assessment process only when the benefit justified the overhead. We used an Intranet to provide easy access to the myriad of documents we created. There were sections to host documents that were relatively stable and areas for documents that were more volatile, requiring rapid changes. We developed a Web database application to hold the exit surveys of all undergraduate courses. The application also allows members of the course committees to enter their recommendations, which were then collected, discussed and approved. We did not use any particular collaborative tool for developing documents. Instead, the committee worked together to finalize versions created by individual members during our meetings. Using a real-time collaborative tool, such as *GoogleWave* (2010), is an experiment we will pursue in the future.

6. CONCLUSION AND FUTURE DIRECTIONS

In higher education institutions, the assessment process is a crucial task that can benefit many stakeholders. Assessment can be a very broad process with no fixed procedure or methodology mandated. In the information technology disciplines, however, there are certain rules and actions that are necessary to accomplish a reasonable assessment. In this paper, we presented a process model and some tools for assessment for information technology programs.

The future direction in this work is twofold: (1) Unifying the terminology and language of the assessment. The definitions of the terms for assessment may lead to different notions in different contexts. Standardized assessment language and terminology will lead to simplifying operations that build upon assessment, like accreditation. (2) Relating model curriculums and accreditation requirements for specific disciplines with assessment models. This aids in using a holistic model to satisfy varying assessment goals. With the entire faculty participating in the assessment process, it was a very positive eye-opener for our program, and assessment was definitely a constructive addition to our program.

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8. APPENDICES

Appendix 1: Program Level Mission Statement (Example)

The mission of the Computer Information Systems program is to prepare students for technical, administrative and management careers in the analysis, design, implementation, maintenance, support, operation and management of computer information systems.
Objectives and Outcomes
Objective #1: Computer Information Systems graduates will be competent in the fundamentals of information systems, computing, and mathematics.
Outcome 1: Students can present the key concepts and principles of computer and information systems.
Outcome 2: Students will be able to effectively solve computing problems using an appropriate programming language, data structures and algorithms.
Outcome 3: Students can use mathematical concepts in the analysis and design of information systems.
CIS Objective #2: Computer Information Systems graduates will understand the role of IS and be able to work effectively within information systems environments.
Outcome 2.1: Student will be able to identify significant opportunities and problems in information systems.
Outcome 2.2: Students will be able to understand the role of information systems in helping individuals and groups make decisions efficiently and effectively.
Outcome 2.3: Students will be able to evaluate the role of information systems in solving significant business problems.

Appendix 2: General Assessment Tools (Example)

1. Examination Analysis [EA]: direct method
a. Instructors map examination questions to specific performance indicators.
b. Curriculum committee and instructors decide whether these indicators are satisfied or not.
c. Curriculum committee and instructors make recommendations.
d. Curriculum committee reviews the assessment results and recommendations.
2. Assignment Analysis [AA]: direct method (including homework, programming and paper assignments)
a. Instructors select assignments that map to specific performance indicators.
b. Curriculum committees assess the assignment to decide whether these indicators are satisfied or not.
c. Curriculum committees make recommendations.
3. Portfolio Analysis [PA]: direct method
a. Every faculty member takes turn to serve in portfolio analysis.
b. A selected group of faculty members assesses specific performance indicators by filling out an assessment rubric.
c. The collected rubric assessment is used to decide whether these indicators are satisfied or not.
d. The group of faculty members makes recommendations.

Appendix 3: Mapping of Objectives, Outcomes and Performance Indicators to Course-Level Assessment (Example)

Objectives #1: Computer Information Systems graduates will be competent in the fundamentals of information systems, computing, and mathematics.
Outcome 1.1: Students can present the key concepts and principles of computer and information systems.

Performance Indicators	Strategies	Assessment Methods	Source of Assessment	Time of data collection	Assessment Coordinator	Evaluation of Results
1.1.1 Identify key concepts and principles of information systems	CINF 3231 CINF 4234	EA or AA, ES	CINF 3231	Fall	Instructor A	Course Curriculum Committee
1.1.2 Evaluate the role of information systems in today's competitive business environment	CINF 3231 CINF 4234	EA or AA, ES	CINF 3231	Fall	Instructor A	Course Curriculum Committee
1.1.3 Demonstrate the understanding of the importance of information systems	CINF 3231 CINF 4234	EA, ES	CINF 3231	Fall	Instructor B	Course Curriculum Committee
1.1.4 Understand fundamental relationship between hardware and software	CINF 3231 CSCI 3331	EA or AA, ES	CSCI 3331	Fall	Instructor B	Course Curriculum Committee

System Testing of Desktop and Web Applications

James M. Slack
slack@mnsu.edu
Information Systems & Technology
Minnesota State University
Mankato, MN 56001, USA

Abstract

We want our students to experience system testing of both desktop and web applications, but the cost of professional system-testing tools is far too high. We evaluate several free tools and find that AutoIt makes an ideal educational system-testing tool. We show several examples of desktop and web testing with AutoIt, starting with simple record/playback and working up to a keyword-based testing framework that stores test data in an Excel spreadsheet.

Keywords: system-testing tools, keyword-based tests, record/playback, AutoIt

1. Introduction

In our software-testing course, we emphasize testing from the quality assurance (QA) perspective in the first half and from the developer perspective in the second. In the second half, students learn about unit testing and write test cases in JUnit (JUnit.org, 2010) and Java to reinforce concepts. This part of the course has worked well for several years.

For the QA half of the course, students learn about system testing and write test cases directly from specifications. An example specification might be that the application is password protected. A system-level test case could try to access a protected area of the application without logging in first.

We needed a system-testing tool to reinforce these concepts on desktop GUI and on web applications. We wanted to use just one system-testing tool that works with both application types, so students spend less time learning the tool and more time learning concepts.

In the Spring 2010 semester, we found that AutoIt (AutoIt, 2010) works well as an educational system-testing tool.

2. Literature Review

System testing evaluates whether the complete system meets its specification by observing the behavior of that system (Pezzè & Young, 2008). System testing involves checking functionality, security, performance, usability, accessibility, among other features. For this paper, we are concerned primarily with functionality system testing: ensuring that the system performs all of its required functions correctly, primarily via the system's user interface.

A particular characteristic of system testing is that it is largely independent of the system's development language (Pezzè & Young, 2008). This means that the tester can use a different programming language and even a different programming paradigm when writing system tests.

Garousi and Mathur state the need for student experience with commercial tools: *"In order to effectively teach software engineering students how to solve real-world problems, the software tools, exercises, projects and assignments chosen by testing educators should be practical and realistic. In the context of software testing education, the above need implies the use of realistic and relevant System Under Test (SUT),* *and making use of realistic commercial testing tools. Otherwise, the skills that students acquire in such courses will not enable them to be ready to test large-scale industrial software systems after graduation." (2010, p.91)*

Garousi & Mathur (2010) found that of seven randomly-selected North America universities, just two use any commercial testing software: the University of Alberta, which uses IBM Rational Functional Tester (IBM, 2010); and Purdue, which uses Telcordia AETG Web Service (Telcordia, 2010). (Both universities also use open-source testing tools.) Of the seven universities in the survey, five use JUnit, usually along with other tools.

Buchmann, Arba, and Mocean (2009) used AutoIt to develop an elegant GUI test case execution program that reads test case information from a text file. For each test case, the program executes a user-defined AutoIt function to manipulate the SUT, and then compares the SUT with expected behavior. The program can check standard Window GUI controls and even images.

3. Evaluation

Evaluation Criteria

We try to give students a QA system-testing experience that is as close to the "real thing" as using JUnit is for unit testing. Ideally, we would use a popular commercial-quality tool such as HP QuickTest Pro (Hewlett-Packard Development Company, 2010) for system testing, but the per-student licensing costs are too high. (We briefly considered licensing commercial software for a lab, but nearly all our students have their own computers and prefer to use them for their assignments.) Therefore, we needed a free, Windows-based tool with these features of commercial-quality tools:

Record/playback: The tool should be able to record keyboard and mouse activity into a script for later playback, so students become familiar with the advantages and disadvantages of this simple technique.

Programmability: The tool should use an easy-to-learn, high-level, interpreted language. This capability allows students to move beyond record/playback, building high-level functions for interacting with the SUT, and to construct their own test frameworks.

Desktop GUI and web application support: The tool should be able to test both major application areas: desktop applications (Windows GUIs) and web-based applications.

External resource access: The tool should be able to access files, databases, spreadsheets, and other resources, so that students can store test data in these places and so they can verify application activity.

Control information: The tool should include the ability to find input and output controls and provide information about them. This capability allows students to write higher-level functions to test the SUT.

Integrated development environment (IDE): The tool should include an easy-to-use environment for building and running tests.

Support: The tool should include complete, well written, and well-organized documentation.

Over the past few semesters, we have tried JUnit, Badboy (Badboy Software, 2010), and Selenium (Selenium Project, 2010) for system testing. In Spring 2010, we decided to examine AutoIt and AutoHotKey (AutoHotKey, 2010). This section compares the relative merits of each of these tools.

JUnit

JUnit was originally designed for unit testing, so it is unsuitable for system testing by itself. However, several third-party utilities add system-testing capabilities to JUnit. For example, we have used HttpUnit (Gold, 2010) and HtmlUnit (Gargoyle Software Inc., 2010) for web testing with JUnit, and Abbot (Wall, 2008) for GUI testing.

We have had some success with these third-party tools, but we have found that both HttpUnit and HtmlUnit execute slowly. Furthermore, neither includes record/playback capabilities. Although Abbot does include record/playback for desktop GUIs, it works only with Java Swing and AWT. These drawbacks motivated us to consider other approaches.

Badboy

Figure 1 shows Badboy, a web-testing tool that includes a script editor and an integrated web browser. Of all the tools mentioned, Badboy is by far the easiest to get started with, because it installs easily and excels at record/playback.

Badboy's integrated help file includes several well-written tutorials.

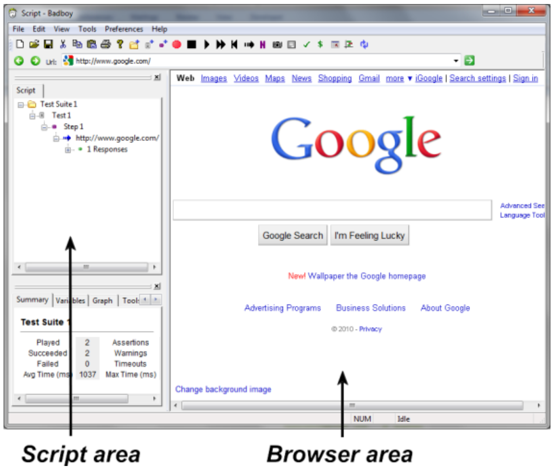

Figure 1: Badboy.

Although Badboy includes load testing, reports, and other valuable features, it has limited programmability and access to external resources, and is useful only for web testing. It cannot test desktop GUI applications, which removes it from further consideration.

Selenium

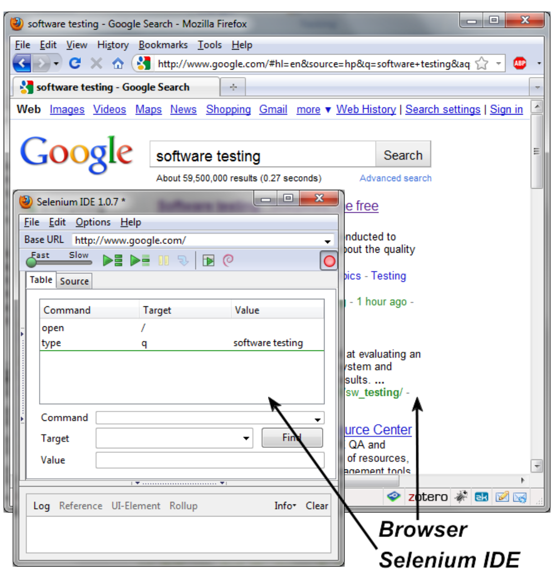

Figure 2: Selenium.

Figure 2 shows Selenium, which is similar to Badboy because it includes a script editor, has very good record/playback support, and only does web testing. In contrast to Badboy, Selenium is a Firefox add-on rather than an integrated application. However, the process of recording and executing scripts is nearly the same as Badboy.

Selenium has a great deal of well-written documentation and an active user community. Selenium can convert its scripts to several different formats, including Java (JUnit), Python, Ruby, C#, Perl, and PHP. This capability makes these scripts easy to customize with higher-level functions and external resources.

Selenium has the same major drawback as Badboy: it works only for web applications. We needed a tool that works with both web and desktop applications.

AutoHotKey and AutoIt

AutoHotKey and AutoIt are each automation utilities for Windows that are very similar to each other. This similarity is not surprising because AutoHotKey started as a fork of AutoIt in 2003 (Wikipedia, 2010).

Neither utility was designed specifically for testing, but they can be used that way because each includes a simple scripting language, record/playback capability, the ability to access external resources, and a simple IDE built on the SciTE editor (SciTE, 2010). They can each generate GUI executables, which is convenient for creating desktop SUTs. Each has a well-written help file and an active user community.

Of the two, we have found AutoIt to be generally more robust and better documented. In addition, AutoIt has a much larger standard library that includes functions for accessing and controlling SQLite databases, Excel spreadsheets, and the Internet Explorer browser. AutoHotKey can do all this, too, but requires installing third-party libraries. (Both can access other external resources with ActiveX.)

Finally, we have found that AutoIt's programming language is easier for students to learn, because it is similar to Visual Basic (VB). In contrast, AutoHotKey's programming language is similar to MS-DOS batch language, which most of our students are not familiar with, in spite of using Windows.

We prefer a VB-like language, because HP QuickTest Pro uses VB, and we want students to get a feel for professional testing tools. Figure 3 shows the AutoIt IDE with a test script at the top, results of the test at the bottom, and a simple SUT created with AutoIt's GUI facility.

Table 1 (in the appendix) summarizes the author's subjective evaluation of the testing tools we considered. The rating scale goes from zero (not present) to five (excellent support). AutoIt emerges as the clear winner in this evaluation.

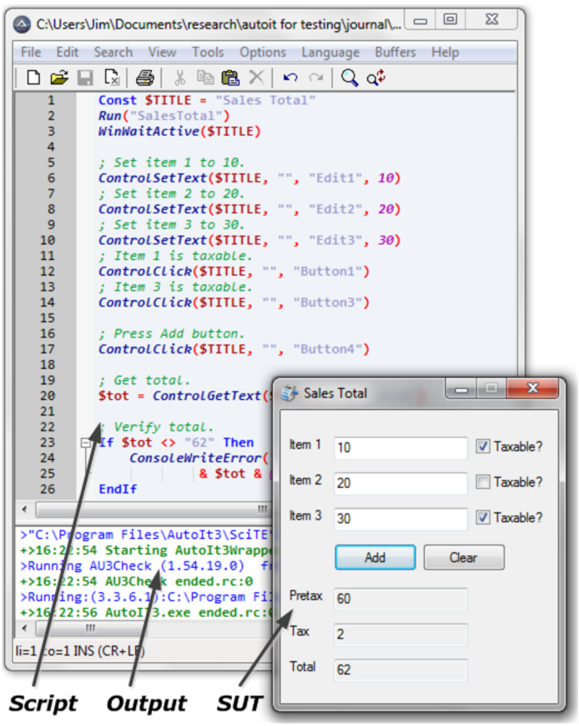

Figure 3: AutoIt.

4. AutoIt Overview

AutoIt is "a freeware BASIC-like scripting language designed for automating the Windows GUI and general scripting."(AutoIt, 2010) (When downloading, make sure to install both the "AutoIt Full Installation" and the "AutoIt Script Editor.")

The language is procedural but not object-oriented. Figure 4 shows an example of an AutoIt function that adds line numbers to a text string. Like PHP, AutoIt requires a dollar sign before each variable name. A comment starts with a semicolon and continues to the end of the line. A statement that continues to the next line must use an underscore at the end of the line as a continuation character. The functions `StringStripWS()`, `StringSplit()`, `UBound()`, `StringFormat()`, and `ConsoleWrite()` are from AutoIt's standard library. String concatenation uses the ampersand (&) symbol. The term @CRLF is a "macro" that signifies an end-of-line sequence of carriage return and line feed.

```
; Returns $text string with a line number
; at the beginning of each line.
Func NumberLines($text)

    ; Strip whitespace.
    $text = StringStripWS($text, 3)

    ; Break into lines (array of strings).
    $lines = StringSplit($text, @CRLF, 1)

    ; Build result string.
    $out = ""
    For $i = 1 To UBound($lines) - 1
        $out &= StringFormat("%d. %s\n", _
                $i, $lines[$i])
    Next
    Return $out

EndFunc

; Test the function.
$s = "first line" & @CRLF _
     & "second line" & @CRLF
ConsoleWrite(NumberLines($s))
```

Figure 4: An AutoIt function.

AutoIt has four different looping statements, including while, do-until, and two kinds of for statements. It also has if-else, select-case, and switch-case selection statements.

The extensive standard library includes many functions for starting and manipulating Windows programs. For example, the code in Figure 5 starts the Notepad text editor, waits for it to finish loading, and then enters some text into the text area.

AutoIt recognizes integer, floating-point, string, Boolean, binary, pointer, and variant types. The only built-in collection type is arrays, but because AutoIt supports COM (Component Object Model), it can also use collection types from .NET and Windows Script. Figure 6 shows an AutoIt program that uses an ArrayList from .NET.

AutoIt's support of COM also allows it to access external resources such as database systems. For example, Figure 7 shows how to query a Firebird relational database with SQL.

```
Run("notepad.exe")
WinWaitActive("Untitled - Notepad")
Send("This is some text.")
```

Figure 5: Start Notepad and enter text.

```
; Define a .NET ArrayList.
$class = "System.Collections.ArrayList"
$list = ObjCreate($class)

; Add elements.
$list.Add("Intel Corporation")
$list.Add("Hewlett-Packard")
$list.Add("General Motors")

; Iterate through the list.
For $company In $list
    ConsoleWrite($company & @CRLF)
Next
```

Figure 6: Using .NET within AutoIt.

5. System Testing Examples

Figure 8 shows a simple SUT: a Sales Total application that sums up to three items, each of which may be subject to a 5% sales tax. For student assignments, we typically include about three deliberate errors in the SUT for students to find.

We wrote the application in AutoIt using its Koda GUI utility and compiled it to an executable with AutoIt's Aut2Exe utility. We also used Aut2Exe's obfuscation option to thwart decompilation, so students cannot simply examine the source code to look for errors.

```
; Create a connection object.
$conn = ObjCreate("ADODB.Connection")

; Connect to the database.
$conn.Open( _
   "DRIVER=Firebird/InterBase(r) driver;" _
   & "DATABASE=C:\\sample.fdb;" _
   & "USER=SYSDBA;PWD=masterkey;")

; Query the database.
$rs = $conn.execute("SELECT Id, Name " _
   & "FROM Person ORDER BY Name")

; Display the results.
While Not $rs.EOF
   ConsoleWrite($rs.fields("Id").value _
       & ", " & $rs.fields("Name").value _
       & @CRLF)
   $rs.MoveNext()
WEnd
```

Figure 7: Accessing a Firebird database.

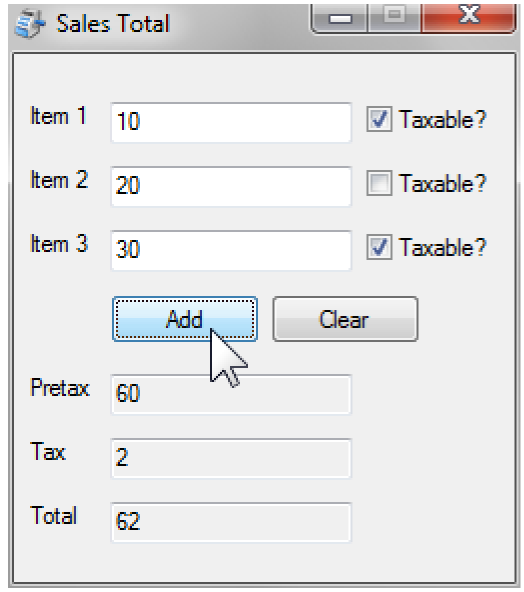

Figure 8: Sales Total desktop application.

Record/Playback Scripting

Students use AutoIt's record/playback utility for their first system-testing assignment. By using record/playback, students see that although record/playback seems to make system testing almost trivial, it has significant problems. (They realize this by the second assignment, described later.)

Students use AutoIt's AU3Recorder to record all mouse and keyboard activity while using the SUT. When the student finishes, AU3Recorder generates AutoIt code to reproduce the student's actions. The result is similar to code shown in Figure 9.

The code in Figure 9 starts the SUT, waits for it to load, enters test data into the fields, and clicks the Add button. Students can manually verify that the result is correct, but manual verification is tedious and error prone, particularly when running many test cases.

```
Run("SalesTotal")
WinWaitActive("Sales Total")
Send("10{TAB}{SPACE}{TAB}20{TAB}{TAB}30")
Send("{TAB}{SPACE}{TAB}{ENTER}")
```

Figure 9: Record/playback without verification.

Therefore, students must add code to Figure 9 to verify that the displayed results are correct. An easy way to capture the displayed result is to tab to the Total field, then copy the value into the clipboard by typing Control-C. The student runs AU3Recorder again, this time copying the total into the clipboard. The student then writes code to compare the contents of the clipboard with the expected value, as shown in Figure 10.

```
Run("SalesTotal")
WinWaitActive("Sales Total")
Send("10{TAB}{SPACE}{TAB}20{TAB}{TAB}30")
Send("{TAB}{SPACE}{TAB}{ENTER}")
Send("{TAB}{TAB}{TAB}{TAB}")
Send("{CTRLDOWN}c{CTRLUP}")

; Verify results (student-added code).
#include <ClipBoard.au3>
If _ClipBoard_GetData() <> "62" Then
    ConsoleWriteError("Expected 62, got ")
    ConsoleWriteError(_ClipBoard_GetData())
    ConsoleWriteError(@CRLF)
EndIf
```

Figure 10: Record/playback with verification.

Of course, one test case is not enough to test this SUT adequately, so students will need to repeat this process with combinations of taxable and nontaxable items, missing items, invalid entries, and so on. The result, which is typically many lines long, is highly sensitive to the layout of user interface controls. For example, if positions of the Add and Clear buttons are reversed, none of the tests will work correctly. Another problem with record/playback is that playback sends individual keystrokes and mouse movements to the SUT, which can be time consuming. After the student has added several more test cases, running these tests takes an inordinate amount of time.

For the second testing assignment, students use the same SUT but with minor changes to the user interface that break their record/playback scripts. Students thus experience the major disadvantage of using record/playback: test cases are extremely sensitive to changes in the user interface. We also fix some errors in the first version of the SUT and add a couple new ones.

We then show students how to access user interface controls directly from AutoIt, rather than by simulated keyboard and mouse activity. Our informal experiments show a speedup factor of about fifteen with direct access. (AutoIt's direct access only works with standard Windows controls, such as those found in Visual Studio. It does not work with nonstandard controls, such as those used in Delphi, QT, Java Swing, or Motif.)

As an example of an AutoIt direct access function, ControlSetText() inserts a text value directly into a text edit control. This standard function takes three parameters: the name of the SUT window, the Windows ID of the control, and the value to insert. AutoIt's AU3Info utility makes it easy to find the Windows ID of a control: simply move the mouse over the control to get its ID. For example, AU3Info reports that the Windows ID of the "Item 1" control in the Sales Total application is "Edit1."

Figure 11 shows how to use ControlSetText() and ControlClick() to insert values directly into the Sales Total application, then retrieve the total with ControlGetText().

Building a System Testing Framework

The approach taken in Figure 11 is simple and straightforward, but does not scale well. The single test case sprinkles its test data over several statements; when the code includes several test cases, it is not apparent whether the test cases are sufficient.

```
Const $TITLE = "Sales Total"

Run("SalesTotal")
WinWaitActive($TITLE)

; Set item 1 to 10.
ControlSetText($TITLE, "", "Edit1", 10)
; Set item 2 to 20.
ControlSetText($TITLE, "", "Edit2", 20)
; Set item 3 to 30.
ControlSetText($TITLE, "", "Edit3", 30)
; Item 1 is taxable.
ControlClick($TITLE, "", "Button1")
; Item 3 is taxable.
ControlClick($TITLE, "", "Button3")

; Press Add button.
ControlClick($TITLE, "", "Button4")

; Get total.
$tot = ControlGetText($TITLE, "", "Edit6")

; Verify total.
If $tot <> "62" Then
    ConsoleWriteError("Expected 62, got " _
        & $tot & @CRLF)
EndIf
```

Figure 11: Direct access.

Therefore, we build a system-testing framework so that writing test cases becomes trivial and the test data is obvious. We have found that students enjoy developing a system-testing framework collaboratively during in-class discussion.

An organizational scheme that we have found useful divides the framework into three files:

- A file of general system testing functions, such as StartSUT(), AssertEquals(), and AssertError() that apply to testing any desktop SUT (see Listing 1 in the appendix),
- A file of support functions specific to a particular desktop SUT, such as entering values into the SUT and verifying results (see Listing 2 in the appendix), and
- A file of test cases as function calls (see Listing 3 in the appendix).

We produced the first eleven test cases in Listing 3 using the *pairwise testing* approach (Cohen, Dalal, Parelius, & Patton, 1996) with the following values:

- For each item: blank, a whole number, and a number with a decimal point
- For each checkbox: True and False (always False when the corresponding item is blank)

The last three test cases insert an invalid value into each item, which should cause the SUT to generate errors.

Each test case is simply a function call, which makes it easy to write and maintain test cases, because testers can concentrate on test cases and test data alone. The format of Listing 3 greatly simplifies verification that the tests cases include all pairs.

Storing Test Data in a Spreadsheet

With a little more work, a spreadsheet can store the test data in a clear and easy-to-use format, as shown in Figure 12. Besides clarity, another benefit of storing test data in a spreadsheet is that students can use formulas to compute expected results.

Figure 12 uses the *keyword-based* format (Nagle, 2010; Fewster & Graham, 1999). This format uses a keyword, typically in the first column, to indicate the kind of test to perform. For example, the keyword "Test" in row 4 indicates a normal test, while the keyword "Error" in row 17 indicates that the given test data should produce an error.

Listing 4 in the appendix shows the OpenSpreadsheet() function that opens an existing spreadsheet for reading. Listing 5 shows the SUT-specific code to read each row of the spreadsheet and call the appropriate SUT-specific function from Listing 2.

	A	B	C	D	E	F	G	H	I	J	K
1	**Test Data for "Sales Total" Application**										
2											
3			***Input Values***						***Expected results***		
4	**Key**	**Num**	**Item1**	**1Tax**	**Item2**	**2Tax**	**Item3**	**3Tax**	**Pretax**	**Tax**	**Total**
5	*Test*	1	10.25	TRUE		FALSE	30.45	FALSE	40.7	0.51	41.21
6	*Test*	2	10	FALSE	20	TRUE		FALSE	30	1	31
7	*Test*	3	10	FALSE		FALSE	30	TRUE	40	1.5	41.5
8	*Test*	4	10	TRUE	20.75	FALSE		FALSE	30.75	0.5	31.25
9	*Test*	5		FALSE	20.75	TRUE	30	FALSE	50.75	1.04	51.79
10	*Test*	6	10.25	TRUE	20	TRUE		FALSE	30.25	1.51	31.76
11	*Test*	7	10.25	TRUE	20	FALSE	30	TRUE	60.25	2.01	62.26
12	*Test*	8		FALSE	20	TRUE	30.45	TRUE	50.45	2.52	52.97
13	*Test*	9		FALSE		FALSE		FALSE	0	0	0
14	*Test*	10	10	TRUE	20.75	FALSE	30.45	TRUE	61.2	2.02	63.22
15	*Test*	11	10.25	FALSE	20.75	FALSE	30	TRUE	61	1.5	62.5
16											
17			***Input Values***			***Expected results***					
18	**Key**	**Num**	**Item1**	**Item2**	**Item3**	**Error message**					
19	*Error*	12	xyz	20	30	Item 1 must be blank or a number					
20	*Error*	13	10	xyz	30	Item 2 must be blank or a number					
21	*Error*	14	10	20	xyz	Item 3 must be blank or a number					

Figure 12: Test data in a spreadsheet.

Web Application Testing

Testing web applications is conceptually the same as testing desktop applications, but can require more setup on the instructor's part. More setup is necessary because students need access to a web application they can install on their own computers (so students do not bog down a shared SUT with tests). Furthermore, the SUT source code must be inaccessible (so students look for errors by testing, not by examining the SUT source). Instructors need to develop web SUTs that either compile to executables or sufficiently obfuscate source code. The resulting web SUT must also be easy to distribute to students and easy for students to install on their computers.

Many approaches meet these requirements for developing web SUTs, and the best choice for a particular instructor depends on the instructor's familiarity with the programming language and tools used by that approach. For example, we teach Python and Java in our introductory programming courses, so we develop our web SUTs in those languages.

Figure 13 shows the Sales Total application converted to a web application using the CherryPy web framework (cherrypy.org, 2010), which uses Python. CherryPy is relatively easy to install and includes its own web server. We distribute CherryPy web applications as compiled Python bytecode to deter students from referring to the SUT source code.

AutoIt's standard library has an extensive collection of functions for accessing and manipulating the Internet Explorer web browser. It includes functions to read and write text on a web page, enter and read form controls, submit forms, follow links, and more. For example, the _IEFormElementCheckBoxSelect() function puts a checkmark in a checkbox.

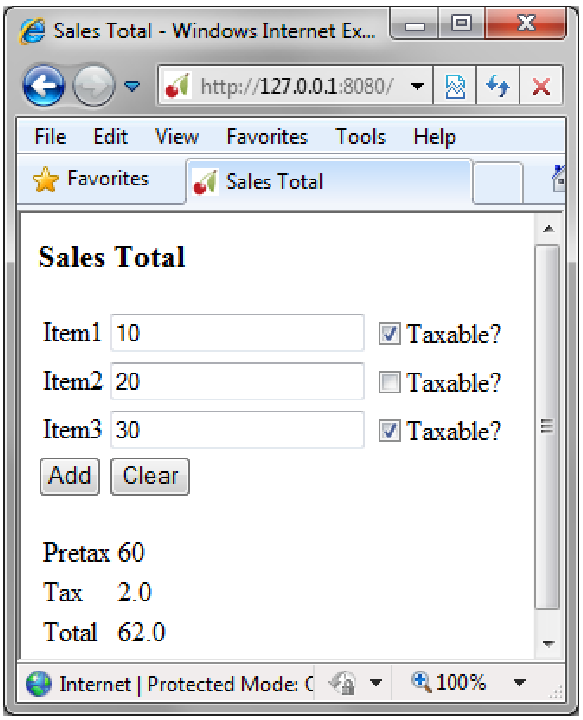

Figure 13: Sales Total web application.

Listing 6 in the appendix shows an example of a single test case for the Sales Total web SUT. Listing 6 is conceptually the same as the code in Figure 11 for the desktop version of Sales Total, and like Figure 11, it does not scale well. We follow the same approach for building a web system-testing framework as we did for desktop applications. That is, we create a file of functions for testing any web application, and another file of support functions for testing a specific SUT. We then put the actual test cases in either a third source file or a spreadsheet.

6. Conclusion

We have been pleased with our selection of AutoIt for system testing. Its VB-like programming language, its ability to test desktop and web applications, its excellent documentation and support, its IDE, and its large standard library make it an excellent, free stand-in for a professional testing tool. Using AutoIt gives students an experience similar to that of professional QA practitioners.

Students experience both the appeal and significant disadvantages of record/playback. They learn how to write higher-level testing functions, organize those functions into a system-testing framework using a keyword-based format that stores test data separately. Finally, they see how using a custom testing framework simplifies the design and implementation of test cases for both desktop and web applications.

Although AutoIt may not be suitable for industrial use (because it cannot access nonstandard desktop GUI controls), it provides an experience similar to using professional tools, and thus makes an ideal educational system-testing tool.

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APPENDIX

Table 1: System-testing tool evaluation summary.

Feature	JUnit	Badboy	Selenium	AutoHotKey	AutoIt
Programmability	1	1	5	2	4
Record/playback	0	5	5	4	4
External resource access	5	2	5	3	4
Desktop GUI and web testing	3	0	0	4	4
Control information	0	4	4	4	4
Includes IDE	0	5	5	5	5
Creates GUI executables	2	0	0	4	4
Support	5	5	5	3	4
TOTAL	**16**	**22**	**29**	**29**	**33**

Listing 1: Testing.au3 (General system testing functions)

```
AutoItSetOption("MustDeclareVars", 1)

; Start the system under test (SUT) if not already running.
; $windowTitle: The window title of the SUT.
; $exeName: The name of the executable file.
; $windowText: Additional text that must appear in the SUT window (optional).
Func StartSUT($windowTitle, $exeName, $windowText = "")
    If Not WinExists($windowTitle, $windowText) Then
        Run($exeName)
    EndIf
    WinWait($windowTitle, $windowText)
    If Not WinActive($windowTitle, $windowText) Then
        WinActivate($windowTitle, $windowText)
    EndIf
    WinWaitActive($windowTitle, $windowText)
EndFunc   ;==>StartSUT

; Ensure that the given condition is true, otherwise log an error.
; $testName: The name of the current test case.
; $condition: The Boolean condition that should be true.
; $message: Optional, additional information to appear with the error.
Func Assert($testName, $condition, $message = "")
    If Not $condition Then
        LogError($testName, $message)
    EndIf
EndFunc   ;==>Assert

; Ensure that the expected value equals the actual, otherwise log an error.
; $testName: The name of the current test case.
; $expected: The expected value.
; $actual: The actcual value.
; $message: Optional, additional information to appear with the error.
Func AssertEquals($testName, $expected, $actual, $message = "")
    If $message <> "" Then
        $message = ": " & $message
    EndIf
    If $expected <> $actual Then
        Assert($testName, $expected == $actual, "Expected " & $expected _
                 & ", but found " & $actual & $message)
    EndIf
EndFunc   ;==>AssertEquals
```

```
; Ensure that a new error message box appears.
; $testName: The name of the current test case.
; $errorWindowTitle: The window title of the error message box.
; $ackButtonName: The name of the button control used to acknowledge the error.
; $errorMessage: The expected error message to appear in the message box (optional).
Func AssertError($testName, $errorWindowTitle, $ackButtonName, $errorMessage = "")
    WinWait($errorWindowTitle, "", 1)
    If Not WinActive($errorWindowTitle, "") Then WinActivate($errorWindowTitle, "")
    WinWaitActive($errorWindowTitle, "", 1)
    If WinExists($errorWindowTitle) Then
        If Not WinExists($errorWindowTitle, $errorMessage) Then
            LogError($testName, "Wrong error message, expected '" & $errorMessage _
                     & "', but found '" & ToOneLine(WinGetText($errorWindowTitle)) & "'")
        EndIf
        ControlClick($errorWindowTitle, "", $ackButtonName)
    Else
        LogError($testName, "Did not get any error, expected '" & $errorMessage & "'")
    EndIf
EndFunc   ;==>AssertError

; -------------------------------------------------------------------------
; Internal functions.
; -------------------------------------------------------------------------

; Report an an error (internal function).
; $testName: The name of the test case that failed.
; $message: The error message to log.
Func LogError($testName, $message)
    If $message <> "" Then
        $message = ": " & $message
    EndIf
    ConsoleWriteError("ERROR in test " & $testName & $message & @CRLF)
EndFunc   ;==>LogError

; Convert a multiline string to a single line.
; $string: The multiline string.
; Returns: The same string but all on one line.
Func ToOneLine($string)
    Return StringStripWS(StringReplace(StringReplace($string, Chr(10), " ") _
            , Chr(13), " "), 7)
EndFunc   ;==>ToOneLine
```

Listing 2: SalesTotalTesting.au3 (Support Functions for testing the "Sales Total" application)

```
#include "Testing.au3"

AutoItSetOption("MustDeclareVars", 1)

Dim Const $WINDOW_TITLE = "Sales Total"
Dim Const $ERROR_WINDOW_TITLE = "Sales Total Error"

; Clicks the Clear button.
Func ClickClearButton()
    ControlClick($WINDOW_TITLE, "", "Button5")
EndFunc   ;==>ClickClearButton

; Clicks the Add button.
Func ClickAddButton()
    ControlClick($WINDOW_TITLE, "", "Button4")
EndFunc   ;==>ClickAddButton
```

```
; Enters values into the application, without pressing a button.
; $item1: The cost of the first item.
; $item1Taxable: If true, item 1 is taxable.
; $item2: The cost of the second item.
; $item2Taxable: If true, item 2 is taxable.
; $item3: The cost of the third item.
; $item3Taxable: If true, item 3 is taxable.
Func EnterValues($item1, $item1Taxable, $item2, $item2Taxable, $item3, $item3Taxable)
    ControlSetText($WINDOW_TITLE, "", "Edit1", $item1)
    ControlSetText($WINDOW_TITLE, "", "Edit2", $item2)
    ControlSetText($WINDOW_TITLE, "", "Edit3", $item3)
    If $item1Taxable Then
        ControlClick($WINDOW_TITLE, "", "Button1")
    EndIf
    If $item2Taxable Then
        ControlClick($WINDOW_TITLE, "", "Button2")
    EndIf
    If $item3Taxable Then
        ControlClick($WINDOW_TITLE, "", "Button3")
    EndIf
EndFunc   ;==>EnterValues

; Ensures that the results are as expected.
; $testName: The name of the currently running test case.
; $pretax: The expected pretax value.
; $tax: The expected tax value.
; $total: The expected total value.
Func VerifyResults($testName, $pretax, $tax, $total)
    AssertEquals($testName, $pretax, ControlGetText($WINDOW_TITLE, "", "Edit4"), "Pretax")
    AssertEquals($testName, $tax, ControlGetText($WINDOW_TITLE, "", "Edit5"), "Tax")
    AssertEquals($testName, $total, ControlGetText($WINDOW_TITLE, "", "Edit6"), "Total")
EndFunc   ;==>VerifyResults

; Runs a testcase by entering the given values, pressing the Add button, and
; ensuring that the results equal the given expected values.
; $testName: The name of the currently running test case.
; $item1: The cost of the first item.
; $item1Taxable: If true, item 1 is taxable.
; $item2: The cost of the second item.
; $item2Taxable: If true, item 2 is taxable.
; $item3: The cost of the third item.
; $item3Taxable: If true, item 3 is taxable.
; $pretax: The expected pretax value.
; $tax: The expected tax value.
; $total: The expected total value.
Func RunTest($testName, $item1, $item1Taxable, $item2, $item2Taxable, $item3, _
        $item3Taxable, $pretax, $tax, $total)
    ClickClearButton()
    EnterValues($item1, $item1Taxable, $item2, $item2Taxable, $item3, $item3Taxable)
    ClickAddButton()
    VerifyResults($testName, $pretax, $tax, $total)
EndFunc   ;==>RunTest

; Runs a testcase by entering the given values, pressing the Add button, and
; ensuring that an error message box appears with the given message.
; $testName: The name of the currently running test case.
; $item1: The cost of the first item.
; $item1Taxable: If true, item 1 is taxable.
; $item2: The cost of the second item.
```

```
; $item2Taxable: If true, item 2 is taxable.
; $item3: The cost of the third item.
; $item3Taxable: If true, item 3 is taxable.
; $expectedMessage: The error message that should appear.
Func RunTestError($testName, $item1, $item2, $item3, $expectedMessage)
    ClickClearButton()
    EnterValues($item1, False, $item2, False, $item3, False)
    ClickAddButton()
    AssertError($testName, $ERROR_WINDOW_TITLE, "Button1", $expectedMessage)
EndFunc   ;==>RunTestError

; Starts the Sales Total application if it is not already running.
Func StartSalesTotal()
    StartSUT($WINDOW_TITLE, "SalesTotal")
EndFunc   ;==>StartSalesTotal
```

Listing 3: SalesTotalTestCases.au3 (Test cases for the "Sales Total" desktop application)

```
#include "SalesTotalTesting.au3"

AutoItSetOption("MustDeclareVars", 1)

StartSalesTotal()
; Tests:   Item1   1Tax   Item2  2Tax   Item3  3Tax   Pretax Tax   Total
RunTest(1, 10.25,  True,  "",    False, 30.45, False, 40.7,  0.51, 41.21)
RunTest(2, 10,     False, 20,    True,  "",    False, 30,    1.00, 31.00)
RunTest(3, 10,     False, "",    False, 30,    True,  40,    1.50, 41.50)
RunTest(4, 10,     True,  20.75, False, "",    False, 30.75, 0.50, 31.25)
RunTest(5, "",     False, 20.75, True,  30,    False, 50.75, 1.04, 51.79)
RunTest(6, 10.25,  True,  20,    True,  "",    False, 30.25, 1.51, 31.76)
RunTest(7, 10.25,  True,  20,    False, 30,    True,  60.25, 2.01, 62.26)
RunTest(8, "",     False, 20,    True,  30.45, True,  50.45, 2.52, 52.97)
RunTest(9, "",     False, "",    False, "",    False, 0,     0,     0.00)
RunTest(10, 10,    True,  20.75, False, 30.45, True,  61.2,  2.02, 63.22)
RunTest(11, 10.25, False, 20.75, False, 30,    True,  61,    1.50, 62.50)
; Errors:        Item1  Item2  Item3  Expected message
RunTestError(12, "xyz", 20,    30,    "Item 1 must be blank or a number")
RunTestError(13, 10,    "xyz", 30,    "Item 2 must be blank or a number")
RunTestError(14, 10,    20,    "xyz", "Item 3 must be blank or a number")
```

Listing 4: SpreadsheetTest.au3 (Support functions for storing test data in a spreadsheet)

```
#include<Excel.au3>

; Returns an Excel spreadsheet with the given title and path.  If the spreadsheet is
; already open in Excel, it returns that spreadsheet, otherwise, it opens the
; spreadsheet.
; $title: The title of the spreadsheet.
; $path: The absolute path (file location) of the spreadsheet.
; Returns: The spreadsheet with the given title and path.
Func OpenSpreadsheet($title, $path)
    Local $oExcel
    If WinExists($title, "") Then
        $oExcel = _ExcelBookAttach($path)
    Else
        $oExcel = _ExcelBookOpen($path)
    EndIf
    If @error <> 0 Then
        MsgBox(0, "Error!", "Unable to open the Excel spreadsheet " & $path)
        Exit
    EndIf
    Return $oExcel
```

```
EndFunc    ;==>OpenSpreadsheet
```

Listing 5: SalesTotalExcel.au3 (Run "Sales Total" test cases from an Excel spreadsheet)

```
AutoItSetOption("MustDeclareVars", 1)

#include "SpreadsheetTesting.au3"
#include "SalesTotalTesting.au3"

Global Const $EXCEL_PATH = @WorkingDir & "\SalesTotalTestData.xlsx"
Global Const $EXCEL_TITLE = "Microsoft Excel - SalesTotalTestData.xlsx"

Func RunTests($testData)
    For $row = 1 To $testData[0][0] ; row count
        Local $keyword = $testData[$row][1]
        Switch $keyword
            Case "Test"
                Local $testName = $testData[$row][2]
                Local $item1Value = $testData[$row][3]
                Local $item1Taxable = $testData[$row][4]
                Local $item2Value = $testData[$row][5]
                Local $item2Taxable = $testData[$row][6]
                Local $item3Value = $testData[$row][7]
                Local $item3Taxable = $testData[$row][8]
                Local $pretax = $testData[$row][9]
                Local $tax = $testData[$row][10]
                Local $total = $testData[$row][11]
                RunTest($testName, $item1Value, $item1Taxable, $item2Value, _
                        $item2Taxable, $item3Value, $item3Taxable, $pretax, $tax, $total)
            Case "Error"
                Local $testName = $testData[$row][2]
                Local $item1Value = $testData[$row][3]
                Local $item2Value = $testData[$row][4]
                Local $item3Value = $testData[$row][6]
                Local $expectedMessage = $testData[$row][7]
                RunTestError($testName, $item1Value, $item2Value, $item3Value, _
                        $expectedMessage)
        EndSwitch
    Next
EndFunc   ;==>RunTests

Global $oExcel = OpenSpreadsheet($EXCEL_TITLE, $EXCEL_PATH)
Global $testData = _ExcelReadSheetToArray($oExcel)
StartSalesTotal()
RunTests($testData)
```

Listing 6: SalesTotalWebTest.au3 (Simple example of single web test case)

```
#include <IE.au3>

; Open the site.
$browser = _IECreate("http://127.0.0.1:8080")

; Get the form.
$form = _IEFormGetObjByName($browser, "salesform")

; Set item 1 to 10.
$item1String = _IEFormElementGetObjByName($form, "item1String")
_IEFormElementSetValue($item1String, "10")
; Item 1 is taxable.
_IEFormElementCheckBoxSelect($form, "item1Taxable")
; Set item 2 to 20.
```

```
$item2String = _IEFormElementGetObjByName($form, "item2String")
_IEFormElementSetValue($item2String, "20")
; Set item 3 to 30.
$item3String = _IEFormElementGetObjByName($form, "item3String")
_IEFormElementSetValue($item3String, "30")
; Item 3 is taxable.
_IEFormElementCheckBoxSelect($form, "item3Taxable")
; Get the Add button (0 = first button).
$addButton = _IEFormElementGetObjByName($form, "button", 0)

; Submit the form.
_IEAction($addButton, "click")

; Verify results.
$pretaxSumObject = _IEGetObjById($browser, "pretaxSum")
$pretaxSum = _IEPropertyGet($pretaxSumObject, "innertext")
If $pretaxSum <> "60" Then
    ConsoleWriteError('Error: pretax sum expected 60, got: ' & $pretaxSum & @CRLF)
EndIf
$taxSumObject = _IEGetObjById($browser, "taxSum")
$taxSum = _IEPropertyGet($taxSumObject, "innertext")
If $taxSum <> "2.0" Then
    ConsoleWriteError('Error: tax sum expected 2.0, got: ' & $taxSum & @CRLF)
EndIf
$totalSumObject = _IEGetObjById($browser, "totalSum")
$totalSum = _IEPropertyGet($totalSumObject, "innertext")
If $totalSum <> "62.0" Then
    ConsoleWriteError('Error: total sum expected 62.0, got: ' & $totalSum & @CRLF)
EndIf
```

Integrating Statistical Visualization Research into the Political Science Classroom

Geoffrey M. Draper
gmd2@byuh.edu
Department of Computer & Information Sciences
Brigham Young University Hawaii
Laie, Hawaii 96762 USA

Baodong Liu
baodong.liu@poli-sci.utah.edu
Department of Political Science

Richard F. Riesenfeld
rfr@cs.utah.edu
School of Computing

University of Utah
Salt Lake City, Utah 84112 USA

Abstract

The use of computer software to facilitate learning in political science courses is well established. However, the statistical software packages used in many political science courses can be difficult to use and counter-intuitive. We describe the results of a preliminary user study suggesting that visually-oriented analysis software can help students query a political data set faster and more accurately than by using traditional non-visual software tools. We hope that our experience will encourage future collaboration between educators in computing and in other academic disciplines.

Keywords: interdisciplinary studies, visual query languages, radial visualization, cross-tabulation, human-computer interaction

1. INTRODUCTION

Computer use in the classroom has gone from a futuristic dream (Ferrell, 1987) to a current reality. As such, educators from multiple disciplines now incorporate some aspect of computing into their curriculum.

One discipline that has embraced computing is political science. University courses in political analysis commonly use statistical software to query and analyze the results of political surveys.

Previous studies show that visualizing the results of statistical queries on a political survey dataset helps students to understand historical and current trends in voter demographics. Indeed, statistical visualization is projected to be "more important and more widespread in political analysis" in the near future (Gelman, Kastellec, & Ghitza, 2009). However, the visualizations produced by conventional statistics software, such as bar charts, pie charts, and line graphs, are fundamentally non-interactive. To visualize a different query, users must return to a different part of the user interface, and produce a new chart. Thus, most statistical software presents two disparate modes of user interaction: one for constructing the queries, another for visualizing the results. This bimodality can be distracting to users, and in the case of students, may actually interfere with the learning process.

One approach to this problem is to unify the actions for formulating queries and viewing results into a single user interface. An example of an information system that implements this concept is *SQiRL*, a prototype software tool originally developed at the University of Utah, and currently maintained by faculty and students at Brigham Young University Hawaii. SQiRL is freely available, and is released under an open source license. Prior research (Draper & Riesenfeld, 2008) indicates that novice users can learn SQiRL's interface in a matter of minutes, and immediately start performing basic statistical analysis tasks. In this paper, we describe a preliminary study suggesting that even experienced users can perform certain types of analysis both more quickly and more accurately using SQiRL than by using conventional statistical software.

We hope that our successful experience of integrating a computer-related research project into a political science classroom setting will encourage other educators in computer and information systems (CIS) to find ways to collaborate across academic disciplines. Although the present study focuses on SQiRL's application in an educational setting, the software itself was designed as a general-purpose data analysis tool, and should be of use in a number of environments.

The remainder of this paper is organized as follows. First, we present a brief review of the SQiRL software. Next, we review current methods used in political analysis. Then, we explain the design and execution of our experiment. Finally, we present our results and identify relevant findings.

2. BACKGROUND

In this section, we briefly review the visualization paradigm employed by the SQiRL system. We also review the notion of the "crosstab", a type of 2D chart for often used for multivariate analysis. Crosstabs are a very common type of chart produced by conventional statistics software.

Interactive Data Analysis Using SQiRL

We now provide a brief review of SQiRL, a research software prototype designed to simplify and enhance the process of discovering relationships within tabular datasets. It features an integrated query interface that supports rapid exploration and "information foraging" (Pirolli & Card, 1995) to focus on global trends in the data. The primary design goal for SQiRL is simplicity of use. It is intended to be easy to learn for naive users, while still providing sufficient power for many of the tasks involved in real data analysis.

SQiRL's user interface consists of a central canvas with a panel on the left (see Figure 1, appendix). The dominant feature of the canvas is a doughnut-shaped widget, or ring. The side panel contains a two-level tree structure of attributes and values. In an opinion poll data set, the attributes represent questions on the survey, and the values represent the range of available answers. Attributes and/or values can be dragged from the side panel onto the canvas. If an attribute is placed on the main ring, a stacked bar chart is mapped onto the ring, to show the percentage of population given each response. As multiple attributes are placed on the ring, the system resizes the sectors so that each attribute is given similar emphasis around the circumference.

While looking at the entire survey population as a whole is beneficial for some applications, most exploratory analysis is concerned rather with uncovering behaviors and patterns for certain segments of the population. To specify a subpopulation, the user selects a value for a given attribute and drags it into the interior space of the ring, i.e., the "doughnut hole." Multiple icons can be placed in this area to further restrict the search to a specific subpopulation. The values are ANDed together; for example, the subpopulation shown in Figure 2 (see appendix) consists of married women who are also Democrats. The bar charts on the ring's circumference are automatically updated whenever a value is added or removed from the ring's interior, or an attribute is moved into or from the circumference. Transitions from one query to the next are smoothly animated to preserve the sense of context (Heer & Robertson, 2007; Yee et. al, 2001).

SQiRL is best used to answer questions of the form: Given a certain subset of the survey population, what percentage manifests a particular characteristic? This involves the selection of independent variables that specify the attributes of the subpopulation to be examined, and dependent variables for which further information is sought. SQiRL's independent variables are represented by icons inside the doughnut hole, while dependent variables are represented by those icons on the ring's circumference (the doughnut's surface). These icons are freely manipulatable, and can be moved from any part of the canvas to any other part. In some ways, this mode of interaction is reminiscent of a pivot table in a spreadsheet, albeit with an arguably smaller learning curve.

SQiRL's interface is based on the direct manipulation metaphor, one in which queries are implicitly constructed by drag and drop operations. Rather than navigate a menu or dialog-based interface, queries are constructed visually on the canvas. There are at least two advantages of using a ring-shaped visualization. First, it increases the accessibility of widgets by placing them equidistant from the center of the canvas (Fitts, 1954). Also, this interface provides a clear delineation: an icon is either inside the ring, on its circumference, or outside of the ring. This reduces the number of "states" that a user has to remember.

Cross-tabulation

A cross-tabulation (or *crosstab* for short) is a tabular method for statistical analysis commonly used in the social sciences. In a cross-tab of two variables, each variable is allocated one axis of the table. The rows and columns correspond to the range of possible values for these variables. Each cell displays the number of times that the combination of values shown in the corresponding row/column occurs.

Each cell in a crosstab typically contains a count, a percentage, or both. Table 1 (see appendix) is an example of a simple crosstab, showing the relationship between political ideology in U.S. voters and how they voted in the 2004 U.S. presidential election (The National Election Studies, 2004). Table 1 indicates the percentage of votes that each candidate received, per ideological group. In this case, "Political Ideology" is the independent variable, inasmuch as it influences the outcome of the dependent variable, "Vote for President."

SPSS is a commercial software package for statistical data analysis. It is frequently used for generating crosstabs from raw data (Norušis, 2006). SPSS files are the *de facto* standard exchange format for distributing data among social science researchers. Consequently, it is often used in university-level political science courses for teaching methods of political analysis. Conforming to this trend, we selected SPSS as the tool used to generate crosstabs in this study.

Our choice of comparing an interactive visual query method against a non-interactive, non-graphical technique like crosstabs might seem contrived at first blush; nevertheless, this choice was based on our observation that crosstabs are one of the most common tools used by political analysts. We felt it was most important to compare SQiRL against the tools that analysts *actually use*, not what they *could* use.

3. METHOD

The user study described herein was conducted in November 2008. The participants, 10 volunteers (primarily students enrolled in a Political Analysis course) were assigned a series of 10 analysis tasks to perform. They used crosstabs in SPSS to answer 5 of the questions, and SQiRL for the remaining 5. The volunteers received no remuneration for their participation in this study.

Purpose

A previous user study (Draper & Riesenfeld, 2008) suggested that the SQiRL interface can be easily learned by novice users with little experience in data analysis. However, in that experiment, SQiRL was independently evaluated, rather than relative to existing tools. The present study aims to fill that gap by comparing SQiRL against current analysis methods. To do this, we needed experienced users, namely, those who are already familiar with popular statistical software. The specific choice of SPSS was influenced by its local usage, since it is the statistics package with which our subjects were most familiar.

Certainly, most commercial statistical software can do much more than simply generate crosstabs; however, crosstabs are a highly prevalent technique for analyzing data. Furthermore, confining this comparative study to crosstabs limited the number of experimental unknowns, and thereby led to a more tractable investigation. It should be noted, however, that

SQiRL is not intended as a drop-in replacement for a full-featured statistics package. Rather, SQiRL is designed to make a certain class of queries, namely finding relationships among two or more variables, faster and easier to perform than by creating and reading crosstabs.

Experimental Design

In the experiment, participants were asked to complete a block of 5 analysis tasks using SPSS, and a block of 5 similar tasks using SQiRL. Each participant completed the same set of tasks. Both sets of questions were based on the NES 2004 data set (The National Election Studies, 2004). While we could have used any number of data sets, we chose NES 2004 because it had been used extensively in the students' coursework during the semester.

The questions were administered by a software-based quiz program which presented the questions as a series of pop-up dialogs (Figure 3). The program recorded the correctness of the user's answer, as well as the elapsed time. When the quiz program started, it randomly selected whether the user would use SQiRL or SPSS first.

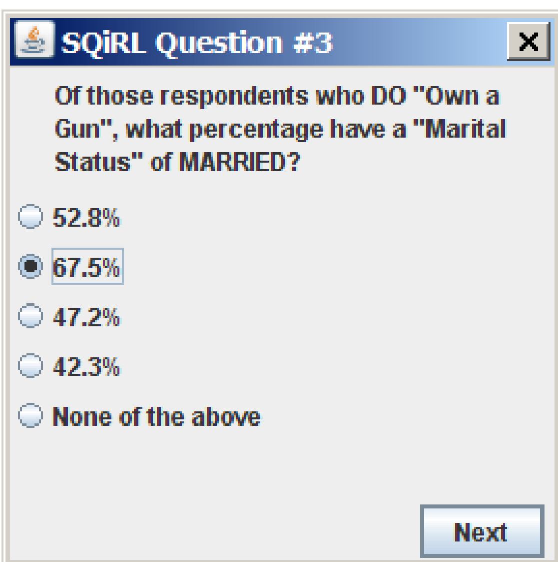

Figure 3: Dialog from the quiz program used in the study.

Prior to each block of 5 questions, the user was also given the opportunity to answer one "practice" question which was neither timed nor scored. This had the twin benefit of giving the user time to start up the current program (be it SPSS or SQiRL), as well as allowing him/her a chance to get oriented with it.

Each question had 4 numeric multiple-choice responses, plus a 5th *None of the above* response. By design, *None of the above* was never the correct choice, and was included only as a "security blanket" to prevent participants from agonizing too long over any particular question.

In addition to the one correct choice, each question also included a wrong choice that the participant would have arrived at if he or she switched the dependent and independent variables in the question. This was done in response to a trend reported previously (Draper & Riesenfeld, 2008), in which users would accidentally put the dependent variable inside the ring and the independent variable on the circumference. Our purpose of including this possible answer in each question was to measure how often participants mixed up these two variables both in SQiRL and in crosstabs. For example, the question shown in Figure 3 asks what percentage of gun owners are married. The correct answer is 67.5%. However, we also include 47.2% as an option in the multiple choice list, which would be the correct answer if the question had been phrased with the dependent and independent variables switched, i.e. "What percentage of married people own a gun?"

Apparatus

The experiment was conducted in a computer lab equipped with 32 workstations. Each workstation consisted of a PC running Windows XP, a LCD display (48 cm x 27 cm) with a resolution of 1024x768, a keyboard, and a 2-button mouse. Subjects were positioned approximately 50 to 60 cm from the screen. Each PC had an Intel Core 2 Quad processor and 3 GB of RAM.

Subjects

Participants were recruited primarily from among students in the Department of Political Science at the University of Utah. Each of the students in the study was enrolled in a Political Analysis course and had approximately 3 months of experience using SPSS. We chose this particular population because of their familiarity with using crosstabs for data analysis.

Although we recorded the users' answers and response times, we did not collect any personally-identifying information about the participants themselves, beyond their names and signatures on the university-required consent forms. The quiz results of each participant were associated with a randomly-generated ID number and no one, not even the proctor, maintained a record of which results corresponded to individual participants. Thus, the data collected in this study was truly anonymous.

Procedure

The experiment began with the proctor giving the participants a brief (approximately 5 minutes) introduction to the SQiRL software, that included a live demonstration displayed via the classroom projector. This presentation served as the participants' sole instruction on using SQiRL. As part of the demonstration, the proctor drew two diagrams on the whiteboard, reproduced in Figure 4. The diagrams were intended to show users where to put icons in SQiRL, placing independent variables inside the ring, and dependent variables on the ring itself.

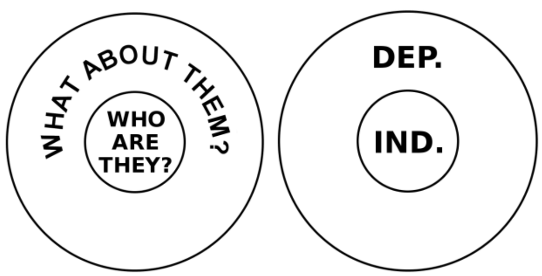

Figure 4: A conceptual look at SQiRL

The circle on the left in Figure 4 casts the problem in layman's terms: how to specify a subpopulation (i.e. "who?") and how to extract statistical information about that subpopulation (i.e. "what?"). The logically equivalent diagram on the right restates the question in terms of independent and dependent variables, a form more familiar to political science students.

These diagrams remained visible to the participants throughout the experiment for reference on where to place dependent and independent variables in SQiRL. Inasmuch as the participants already had 3 months' experience creating crosstabs in SPSS, no time was spent reviewing how to do this. Each participant completed the quiz individually, not as a "group project." After the demonstration, the participants were instructed to start the quiz program, which then, in turn, told them to launch either SPSS or SQiRL, depending on which program they were randomly assigned to use first. Upon completing the first 5 tasks, the quiz program instructed them to close the program in use and then launch the other prior to completing the second block of questions. To eliminate any chance of ambiguity over a task's meaning, the phrasing of the tasks reflected the variable names used in the NES 2004 data set. At the conclusion of the tasks, the quiz program offered the participants the option of submitting written comments about the experience. The participants were then dismissed, and their responses were collected by the proctor for offline analysis.

Analysis Tasks

Enumerated below are the 10 tasks that participants were to asked to complete. As each requires the use of exactly one independent and one dependent variable, they are all of essentially equivalent difficulty. Each question is phrased such that the independent variable appears first, and the dependent variable second. The participants completed half of the questions using crosstabs, and the other half with SQiRL.

1. Of those whose *Education Level* is "some college," what percentage attend religious services every week?

2. What percentage of people who *invest in the stock market* say they CAN afford needed health care?

3. What percentage of married people do NOT have any children in the household?

4. What percentage of people who voted for Al Gore in 2000 also voted for John Kerry in 2004?

5. Of those who identify their *Patriotism* as "low," what percentage "care a good deal" about who wins the presidential election?

6. Of those respondents whose *Ideology* is "conservative", what percentage have a *Patriotism* of "high"?

7. Of those respondents whose *Race* is "white," what percentage are "strongly opposed" to *Affirmative Action*?

8. Of those respondents who do own a gun, what percentage have a *Marital Status* of "married"?

9. Of those respondents whose *Frequency of Prayer* is "once a day," what percentage have a *Party Affiliation* of "Democrat"?

10. Of those respondents who voted for Kerry in 2004, what percentage had an *Annual Income* of over $60,000?

4. ANALYSIS

For a given task, we found that the two main benefits of using SQiRL over manually generating crosstabs were *speed* and *accuracy*. We now discuss each in turn.

Decreased Response Time

Each participant completed the analysis with SQiRL in less time than with crosstabs. The time differential for each participant was very user-dependent; some saw great speedups with SQiRL, others' were more modest. Nonetheless, no participant completed the questions faster using crosstabs than using SQiRL. The total response times per user are shown in Figure 5 (see appendix). The mean times for performing the tasks were 245 seconds and 398 seconds for SQiRL and crosstabs, respectively. The average speedup was 38% with SQiRL.

The improvement in elapsed time is more impressive considering that the participants had months of experience using crosstabs in SPSS, versus only minutes of introduction to SQiRL. So the times reported above include not only the time spent finding the answer, but also time spent learning the interface. We believe that the speedups would have been even greater had we given the participants more practice time with SQiRL prior to the quiz.

Improved Accuracy

Participants also made fewer mistakes on average using SQiRL than with crosstabs. While the improvement in accuracy is encouraging, it does not tell the whole story. It is perhaps more insightful to look at the kinds of mistakes participants did make, both with SQiRL and with crosstabs. Recall that students in political analysis commonly exhibit the mistake of switching the independent and dependent variables, thus answering the converse of the intended question. We observed that participants occasionally fell victim to this error regardless of the program used. However, as shown in Figures 6 and 7 (see appendix), with SQiRL this type of error occurred rather less frequently than with crosstabs.

In summary, we found that SQiRL users achieved more accurate results, while there was also a diminished occurrence of one of the most common mistakes.

As shown in Table 2, the mean score using SQiRL was 3.9 correct out of 5 questions. Using crosstabs in SPSS, their mean score was 2.8 correct out of 5 questions. With SQiRL, they averaged 0.8 incorrect responses from switching the independent and dependent variables, and 0.3 incorrect for other reasons. Using traditional crosstabs, an average of 2 questions per user were answered incorrectly due to switching the independent and dependent variables, with 0.2 questions incorrect for other reasons.

	Correct	**Incorrect (ind/dep)**	**Incorrect (other)**
SQiRL	3.9	0.8	0.3
Crosstabs	2.9	2.0	0.2

Table 2: Mean accuracy with SQiRL and crosstabs (out of 5 questions)

5. DISCUSSION & FUTURE WORK

We found the results of our study to be very promising for the use of visual and interactive data analysis in future political science classroom teaching. SQiRL was initially designed as a simple interface for novice users; little attention was given to whether it could be an effective tool for people who have prior experience with data analysis (Draper & Riesenfeld, 2008). The study presented in this paper suggests that even experienced users can perform basic analysis faster and more accurately using an interactive direct manipulation technique for query formulation and visualization.

Although SQiRL is not intended to completely replace the traditional statistical methods such as crosstabs, this paper suggests the power of statistical visualization for student learning. More importantly, an interactive way of "exploring" political data is a powerful tool that political science students should learn to use in the future. Informal written feedback from the participants included comments such as:

- "I loved how SQiRL [made it] easy to know what item was to be placed in what area."

• "I liked how visually accessible the squirl [*sic*] program was."

• "SQiRL was a lot quicker [than] doing and reading cross tabs. It also was easier to understand exactly what I was studying."

Another potential avenue for future research would be to compare SQiRL against other statistical software packages. SAS is a competitor to SPSS, and would be a logical choice for comparison.

Statistical visualization is certainly still in its infancy, and this study suggests one area for improvement. In our case, some participants observed that while SPSS keeps a history of which crosstabs the user generated in the current session, SQiRL has no equivalent feature. In other words, SPSS makes it trivial to go back and view previous queries, while SQiRL shows only the current state of the system. The importance of "computational provenance," (Silva & Tohline, 2008) the ability to trace a computational process over time, has attracted considerable interest in recent years (Freire, Koop, Santos & Silva, 2008). As a future extension, an interface such as the one described by Callahan, Freire, Scheidegger, Silva & Vo (2008) could be adapted to seamlessly and automatically maintain a record of prior queries, and allow the user to revisit any previous state.

6. CONCLUSIONS

In hindsight, there are a few key practices that appear to have influenced this project's success as an interdisciplinary effort. Although our collaboration was between CIS and political science, the points listed below should be adaptable to a variety of disciplines.

1. Meet often with your collaborators. Learn their vocabulary. Learn what tools they use in their work. For example, our decision to evaluate SQiRL against crosstabs was a direct result of conversations with political scientists.

2. Suggest a CIS solution that addresses one of the challenges in their work. In our case, SQiRL was proposed to address many of the perceived shortcomings in crosstabs.

3. Demonstrate the technology to, and get feedback from, stakeholders who will be affected if the technology is adopted. For us, this early iterative feedback led to a number of suggested improvements that were eventually implemented in SQiRL.

While educators in many disciplines have embraced the use of technology in the classroom, they may not necessarily be aware of current research in CIS. This leads to a tendency to use familiar, albeit dated, tools for classroom instruction. This paper describes a case study in which incorporating novel CIS research into a political science course led to measurable improvement in students' ability to formulate statistical queries. It behooves us, as educators and researchers in CIS, to "reach out" across disciplines and share advances in computing with educators in other fields.

Those interested may download the SQiRL software and documentation from:
http://draperg.cis.byuh.edu/sqirl/

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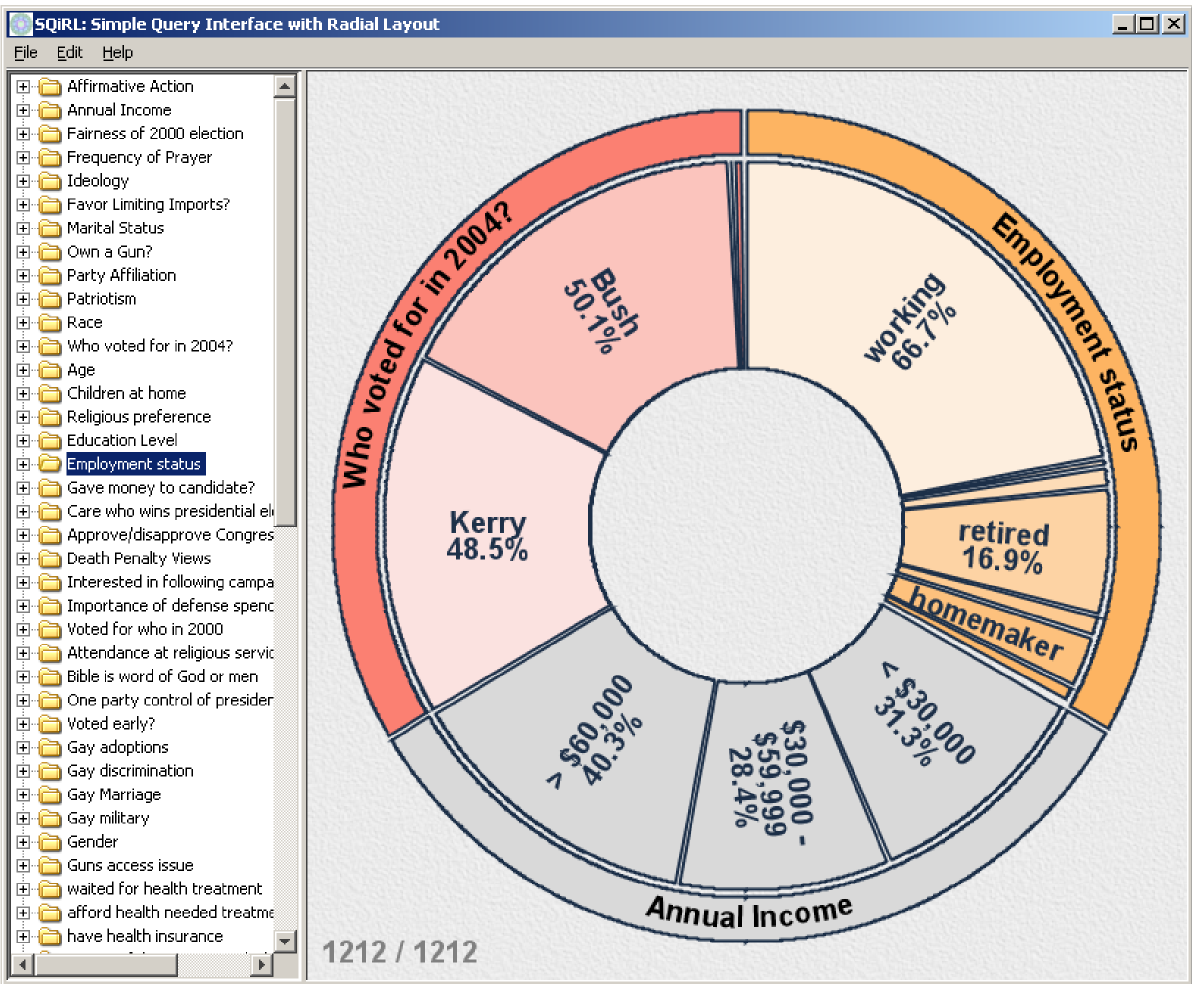
Appendices

Table 1: Example of a Simple 2-Variable Crosstab
("Political Ideology" versus "Vote for President". Source: The National Election Studies, 2004)

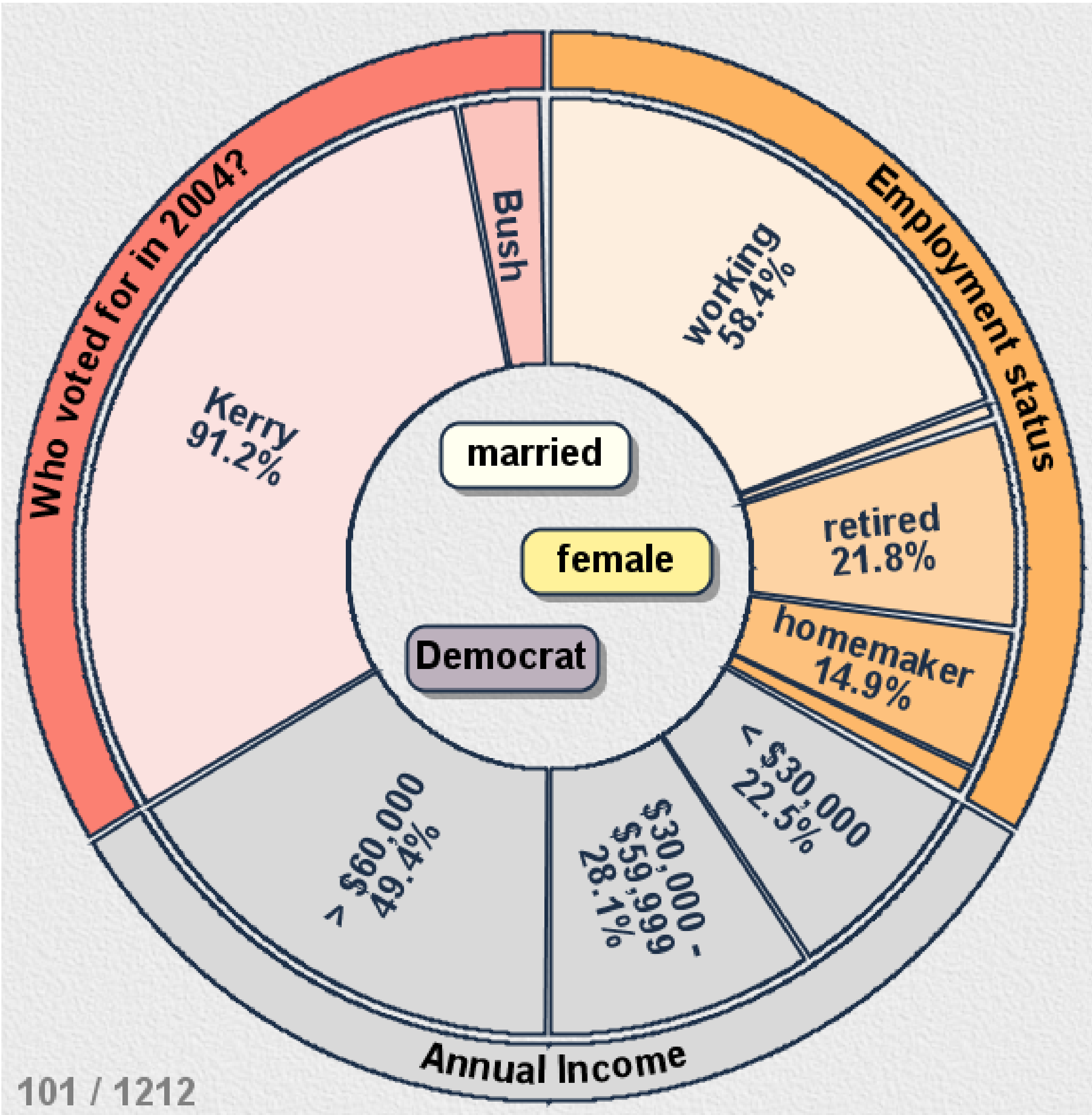
	Kerry	Bush	Nader	Other	Total
Liberal	155 (89.6%)	15 (8.7%)	1 (0.6%)	2 (1.2%)	173 (100%)
Moderate	106 (55.2%)	84 (43.8%)	1 (0.5%)	1 (0.5%)	192 (100%)
Conservative	50 (16.3%)	250 (81.7%)	2 (0.7%)	4 (1.3%)	306 (100%)
Total	311 (46.3%)	349 (52.0%)	4 (0.6%)	7 (1.0%)	671 (100%)

Figure 1: Screenshot of SQiRL, viewing the NES 2004 data set



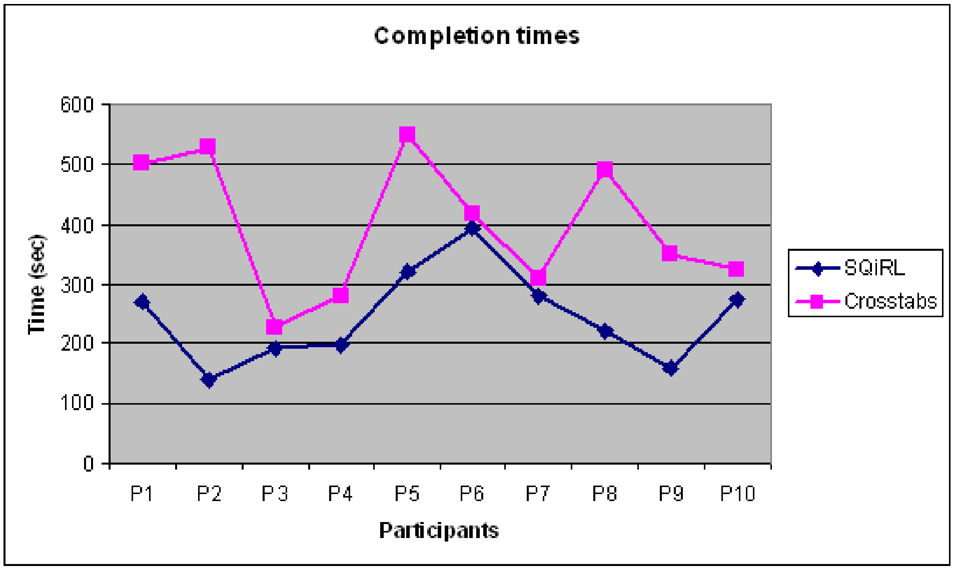
A few attributes relating to voter opinion and demographics appear on the ring, with no qualifiers restricting the size of the sample population.

Figure 2: SQiRL presenting demographic statistics for a specific subpopulation



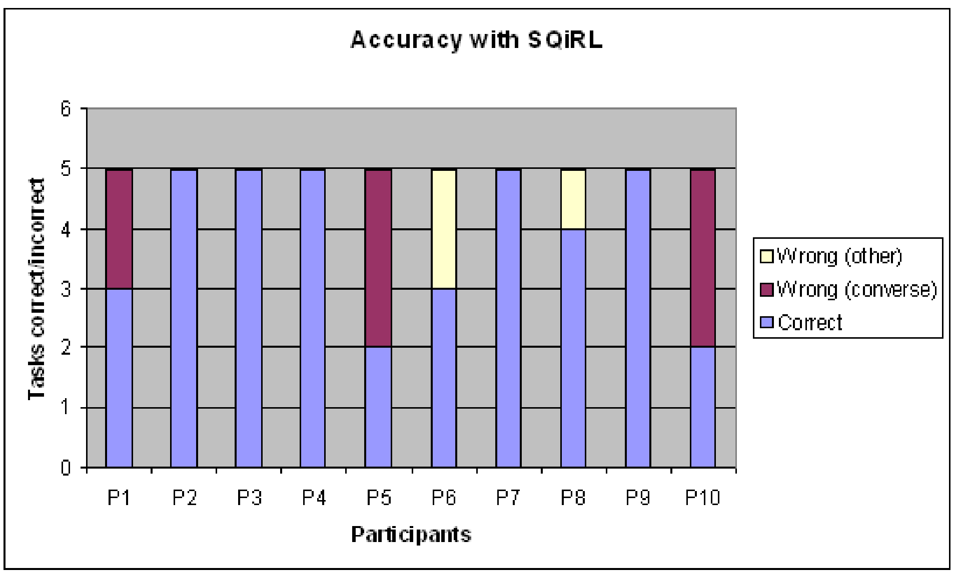
The current subpopulation is specified by dragging icons for attributes' values into the interior of the ring. The percentages in the sectors reflect the decomposition by attribute of the population. The size of the subpopulation relative to the total population is shown in the lower left corner of the canvas.

Figure 5: Total elapsed time for participants to complete the tasks using SQiRL versus crosstabs.



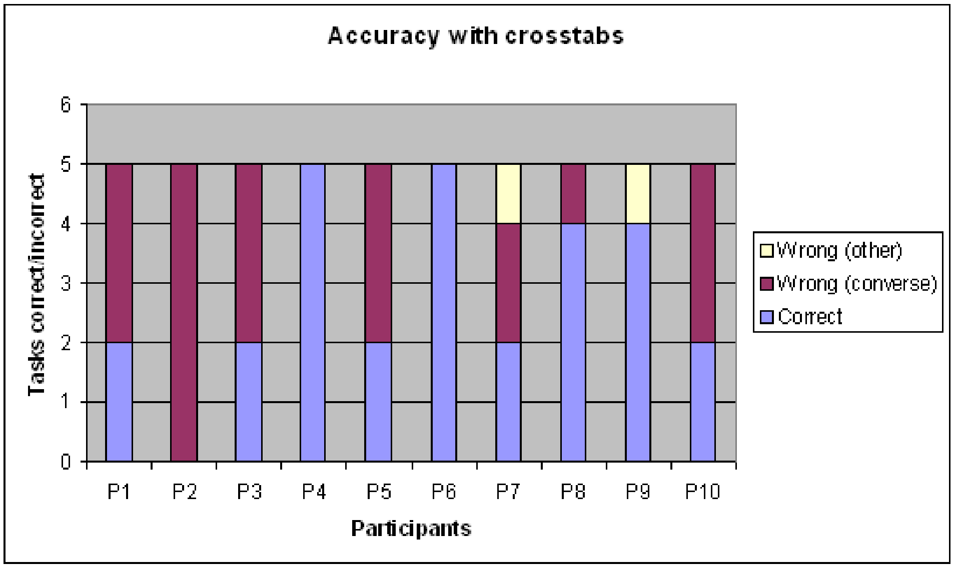
The x-axis shows the individual participants; the y-axis is the completion times in seconds for each tool. Interestingly, each participant completed the tasks more quickly with SQiRL than with cross-tabs, although the speedup varied greatly for each individual.

Figure 6: Users' accuracy using SQiRL



Participants' total number of correct and incorrect responses to 5 analysis tasks, using SQiRL. The x-axis shows the individual participants (P1..P10); the y-axis represents responses the 5 questions. Incorrect responses are categorized as those that were due to switching the independent and dependent variables ("converse"), and those that were wrong for other reasons.

Figure 7: Users' accuracy using crosstabs



Total numbers of correct and incorrect responses to 5 analysis tasks, using crosstabs. The x-axis shows the individual participants (P1..P10); the y-axis represents responses the 5 questions. Incorrect responses are subdivided into those due to switching the independent and dependent variables ("converse"), and those that were wrong for other reasons.