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# INFORMATION SYSTEMS EDUCATION JOURNAL

# More Technology, Less Learning?

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## Abstract

Modern information technologies (presentation software, wireless laptop computers, cell phones, etc.) are purported to enhance student learning. Research to date provides an ambivalent and often conflicting set of outcomes about the effectiveness of such technologies in the context of the college classroom. Anecdotal evidence further complicates this matter by presenting viewpoints which often conflict with existing studies and prevailing best practices. Do modern technologies belong in the classroom and to what extent? The answers to these questions are neither direct nor simple. This paper integrates the results of published studies, anecdotal evidence, and theory, and considers the potential drawbacks of an over reliance on modern technologies to the learning process in higher education.

**Keywords:** Learning, Education, Technology

## 1. INTRODUCTION

Institutions of higher education are often at the forefront of technological progress and the adoption of new technologies. Cutting edge technologies are standard equipment in many classrooms. The term 'ubiquitous computing' describes the phenomenon of a campus environment connecting students and faculty by means of Wi-Fi technologies (Fried, 2008). The use of fixed-position technologies created an 'e-learning' environment. Now, the proliferation of portable devices has resulted in a shift to mobile learning, or 'm-learning' (Wurst et al., 2008). Some have raised concerns over the effectiveness of the learning process in these new environments (e.g. Fried, 2008).

Contemporary e-learning and m-learning technologies do not guarantee a superior learning experience. Reliance on these technologies may actually result in decreased student interest and participation, increased distraction, decreased classroom participation, and increased complexity of knowledge dissemination. Although such technologies are undoubtedly appropriate in specific and specialized cases, the benefits are neither universal, nor as significant as their advocates might suggest. This paper considers the potential pitfalls of contemporary e-learning and m-learning technologies in higher education, and examines a view of best practices which can increase the chances that these technologies will help, rather than hinder the learning process.

## 2. TECHNOLOGIES CONSIDERED

We specifically consider the following three technology categories: presentation hardware and software, laptop and notebook computers, and cell phones and smart phones. These also encompass related software-based components (e.g. presentation software), and hardware-based components (e.g. projectors). This serves as an informal aid to explaining and understanding current uses of technology in the classroom rather than suggesting a formal taxonomy.

These technologies are all intended to be used for the academic purposes of presentation, information retrieval, communication, or authoring within the classroom environment (Bugeja, 2007). Presentation hardware and software present data in a multi-media format, presumably to facilitate viewing of information and note-taking. Commonly used presentation platforms include Microsoft PowerPoint and course management software systems such as Blackboard and WebCT (Young, 2004). Laptop computers are used for note taking, to access the Internet for information retrieval and messaging, and author document management. The overwhelming majority of laptop computers are equipped for wireless Internet access (Young, 2006). Cell phones and smart phones may serve a similar purpose, but are differentiated by their much smaller form factors, and the use of cellular rather than local wireless networking. Like laptop computers, they are used for information retrieval and to send messages (Bugeja, 2007). The described functionalities are by no means the sole capabilities of these technologies, but reflect their typical roles in academic environments.

## 3. TECHNOLOGY AND LEARNING

We now consider different aspects of technology use in university classrooms, and the extent to which it can interfere with the learning process, negating the benefits it would otherwise have. The previously noted effects of decreased student interest and participation, increased levels of distraction, decreased classroom participation, and increased complexity of knowledge dissemination are part of this analysis.

### Decreased Student Interest and Participation

Educational institutions use the appeal of technology to attract students (Schwartz, 2003). Academicians advocate technology as a means of engaging students in learning material rather than simply presenting it (Young, 2005). Research suggests that students are more engaged with classroom material when it is accompanied by technology (Wurst et al., 2008). Technology is widely perceived as a means of increasing interest in learning. The counter argument is that students are more interested in the technology, and not focused on the learning.

Instant access to a wealth of largely unfiltered information creates a disincentive to learning. Students do not need to formulate potential answers, think about causes and effects, or think critically - they can simply find "an" answer. This removes interest and excitement from the prospect of learning and exploration. Students find the information interesting, but they have not engaged in the quest for knowledge. Technology has made learning an empty quest which removes thinking or understanding from the learning process.

While technology seems to increase enthusiasm for learning, it may really distract from the students' learning processes. Students pay more attention because of the entertainment value of using technology rather than any added learning value. Unfortunately, this creates the illusion of increasing interest in learning. Technology may also act as a crutch, further compounding the problem of decreased passion for learning. The use of technology may reduce curiosity and enthusiasm for learning. Meierdiercks (2005) states that technology creates an unhealthy dependence, neutralizing students' abilities to think, analyze, and understand. Because technology does it for them, students cease being able to forge knowledge themselves. In sociological terms, technology creates its own social forces that we, its creators, have lost the ability to regulate.

As students increasingly depend upon technology as a surrogate for thinking, analyzing, and understanding, they may fall into the trap of depending upon faulty, inaccurate, or even malicious sources (e.g. Wiki-based). This may not only hinder the learning process, it may negate what students have already learned.

As with virtually every technology adoption model, educational technology ultimately possesses its dark side. While all students and learning environments may not fall prey to the trap of decreased interest in learning, or excess dependence on technology, these dangers clearly exist. It seems unlikely that all students will lose their ability to think and reason for themselves as a consequence of technology, but such arguments raise credible concerns about the role technology has in education. Traditional learning occurs under the guidance of instructors who present accurate and reliable information, promoting investigative activities. This is the very definition of pedagogy. Uncontrolled access to information (both reliable and unreliable) may change this process dramatically by shifting the locus of learning control away from the competent instructor to unknown resources that are easily accessible with modern technology. Technology-augmented learning may rapidly tend towards androgogy, synonymous with educational anarchy in environments where students are not yet qualified to be peers.

**Increased Distractions**

Many educational institutions require students to use mobile computing technologies, presumably as a means to improve the learning experience. Representative examples would include Seton Hall (Collins, Easterling, Fountain, & Stewart, 2004), Temple (Wurst et al., 2008), and the Darden Graduate School of Business at the University of Virginia (Leibowitz, 1999). This is increasingly common at the secondary education level as well. Presumably, students and faculty will use information technologies to enhance communication, collaboration, and understanding (Collins et al., 2004). Unfortunately, besides interfering with student interest in learning, technology has the potential for significant distraction, which has a negative effect on the very areas it was intended to improve.

Technology in learning environments requires multi-tasking. In pre- or non-technology environments, students have had a single, interactive resource (the instructor) and various passive resources (texts, handouts, etc.). Technology introduces several additional interactive information resources that have the potential to draw student attention away from learning objectives.

Humans have a finite capacity to process information. Dealing with concurrent sources of information can create cognitive overload, resulting in distraction (Fried, 2008). Multi-tasking and multiple information sources greatly increase the likelihood that humans become distracted, shifting their attention from one source to another and not giving certain sources the attention that they deserve. Fried (2008) notes that when attention is divided and attention demands exceed capacities, task performance suffers. Indiscriminately adding technology into the classroom mix may cause students and instructors alike to become distracted from the intended task at hand: learning.

Unfortunately, technology distraction and its effects are not limited to immediate users and may spread to anyone in the vicinity. Fried (2008) suggests that laptop use in the classroom is more likely to cause distraction than other common sources of disruption such as private conversations, students entering and/or leaving a class environment, or the time of day. The nature of certain devices invariably allows for observation and potential interaction by indirect users or observers. When students engage in non-academic activities with technology, others nearby will almost certainly notice. This draws attention away from the intended activity. Students may actively share disruptive activities, such as an amusing image or message (Schwartz, 2003). Similar opportunities exist with text pagers, cell phones and smart phones which, apart from ringing and going off in class, allow messaging and Internet browsing (Bugeja, 2007). Even a moderate number of such devices in a single classroom may severely disrupt the normal flow of information from instructor to student.

Distractions in classrooms are nothing new. Students have always talked, passed notes, daydreamed, slept, or just doodled (Bugeja, 2007). However, technology greatly increases the potential and opportunity for disruption, as well as the potential to spread to others. In the past, students might have been limited to a relatively small number of distractions; however, this number has exploded. A single technological device brings many more distractions to the classroom now than any other single item. Students may now play hundreds of games, check e-mail, chat, and view photos, and they can watch full-length movies (Schwartz, 2003). There is a concern that we have provided students with a multimedia contraption and a challenge to remain focused on learning (Meierdiercks, 2005). Instructors who once enjoyed the luxury of a relatively captive audience now must frequently compete for attention with something highly entertaining, and often lose.

The presence of interactive technologies in teaching environments makes increased distraction inevitable. The necessity of multi-tasking, an increased number of information sources, informational content, the technology itself, or other people using it, all serve to make the learning environment more complicated. Distractions have always existed, but technology pushes the limit, preventing students from paying attention when they should. Many claim that technology may be sufficiently controlled to prevent distraction from corrupting the learning process (Young, 2005), but there is a constant threat that students will find alternative uses for the technology more compelling or entertaining than the topic at hand. When this occurs, it affects not only one individual, but all others in range. Technology cannot always be thoroughly controlled and focused on educational objectives. This introduces widespread opportunities for deviation from the primary educational objectives.

**Decreased Classroom Participation**

Increased technology-based distraction in the classroom is negatively correlated with classroom participation. Many universities have invested heavily in smart classrooms which feature high-tech components in hopes of creating more interactive and enriching learning environments (Schwartz, 2003). Such environments are believed to be more conducive to constructivist teaching methods, an instructional paradigm emphasizing the ability of a student to construct unique mental representations of material rather than recording and remembering it (Wurst et al., 2008). These environments are allegedly more active, dynamic, and collaborative than their conventional counterparts. Technology usage would be expected to complement this model (Wurst et al., 2008). Unfortunately, neither traditional nor constructivist environments are immune to the adverse effects of technology. Indeed, constructivist environments may be at greater risk due to the focus on technology-facilitated collaboration. Instructors in both types of environments are witnessing the adverse effects of technology on student participation.

Student participation typically enhances the learning process by promoting new ideas and fostering critical discussion. It also gives instructors feedback on student comprehension of course material and progress. However, Professor Dennis Adams at the University of Houston grimly notes the dark side of technology:

> You can be in the front of the classroom and your hair could catch on fire and they'll never see it because their eyes are glued to the 14-inch screen at the end of their nose (McWilliams, 2005).

Technology distraction can cause students to miss the 'give and take' of exchanging ideas via discussion (Schacter, 1999). Such discussions are fundamental to understanding content and developing thinking skills. However, simple technology distractions are not the only obstacle to participation. June Entman, a law professor at the University of Memphis, states that laptops in the classroom create a wall of vertical screens that hampers the flow of discussion between the instructor, the class, and among the students (Young, 2006). Mobile technologies may create physical, as well as logical, barriers to participation. However, rather than removing the barrier, technology remains because of its perceived value. This persistent barrier to participation and learning should at least raise concern regarding the universality of technology in learning environments.

In addition to missing important classroom discussion and information interchanges, lack of student participation affects instructor control of the classroom. Kenneth Brown, a professor at the University of Iowa business school, notes that even in larger lecture classes the instructor is very sensitive to whether people are paying attention, and uses that information for appropriate delivery of the material (Young, 2006). If student attention is focused on technology rather than instructors, valuable feedback regarding instructional effectiveness is lost. Lack of participation makes it harder for instructors to "read" a classroom and determine how to proceed. For example, students may clearly understand presented material, but impaired feedback due to technology distraction may skew instructor perceptions, reducing instructor efficiency, effectiveness, or both. This becomes a vicious circle as students subsequently find the instructor's presentations boring or repetitive.

As previously noted, constructivist learning environments encourage investigation of topics with high levels of collaboration and cooperation, with instructors providing directions and guidance, as opposed to dictating information (Wurst et al., 2008). A study at Temple University considered the effect of laptop computer usage in the classroom on constructivist activities. The use of laptops presumably would allow students to instantly retrieve information which would be helpful for classroom discussion and activities (Wurst et al., 2008), and this would enhance constructivist teaching. Contrary to expected outcomes, laptop computer usage did not increase constructionist activity in the classroom, and may in fact have significantly reduced it (Wurst et al., 2008). The surprising findings of this study suggest that, despite the ability of technology to provide instant information which could be used to promote learning, it does not necessarily do so. One student interviewed during the study (Wurst et al., 2008) indicated that the laptop environment was beneficial to learning but it did have its drawbacks. Specifically, it was hard to pay attention when able to email friends or talk to them online while in class. Undoubtedly, the student noticed that while information accessible via the laptop was helpful, it caused classroom attention and participation to suffer.

The potential for technology enhanced processes is not always realized. Technology has the potential for positively influencing classroom discussion and participation. However, students frequently fail to learn from and participate in classroom discussion and activities when technology intervenes. Instructors are unable to get proper feedback from students about how to conduct the class. Students frequently prefer interacting with technology to participation in their classroom environments. Data from the field suggest that technology diminishes classroom participation, increasing the difficulty for instructors to obtain feedback required to tailor their teaching to the classroom environment.

**Increased Complexity of Knowledge Dissemination**

Using technology in higher education increases the complexity of learning, due to the complexity of the technology, and the ambiguity concerning its benefits. Traditionally, instructors have used blackboards (or whiteboards) and overhead projectors in order to convey information to their students.

The proliferation of technology has manifested itself in a larger scale use of more technically sophisticated methods such as animated PowerPoint presentations, Blackboard course-management software, and interactive websites (Young, 2004). Widely touted as the way of the future, these changes are not necessarily resulting in improved outcomes. The use of such technologies inherently complicates a process which had previously been quite direct and simple. A problem domain once limited to a lack of chalk or an eraser, or a dried out transparency marker, now includes malfunctioning technology, forgotten passwords, slow login times, version incompatibilities, and complicated presentation software.

Other than student laptop computers, another of the ubiquitous technology components is the video projector hooked up to a computer station with presentation graphics software. The undisputed leader of this market segment is Microsoft PowerPoint. Originally developed for commercial and business use, PowerPoint quickly displaced the previous de facto academic standard, Harvard Graphics, and is the preferred method of visually presenting information in the classroom (Szabo & Hastings, 2000). PowerPoint allows for the display of text, graphics, and multimedia content to illustrate points, organize lectures, and generally disseminate information to the occupants of a classroom or conference room. Such presentations are generally well received by students. Research by Bartsch and Cobern (2003) indicates that students prefer such presentations to the use of traditional (static) overhead transparencies and the blackboard. Unfortunately, research regarding the effectiveness of PowerPoint presentations with respect to learning outcomes has been inconclusive. Szabo and Hastings (2000) found positive effects upon learning performance, Bartsch and Cobern (2003) contradict their findings. PowerPoint presentations do not have a universally positive effect on outcomes, otherwise these conflicting results would not be observed. There is the grim sarcasm that the use of PowerPoint lowers the effective IQ in a room (Tufte, 2003).

With very few exceptions, students *prefer* PowerPoint presentations over other traditional forms of presenting material due to their interest in the technology itself – not because of the positive effect it has upon their learning. Szabo and Hastings (2000) caution that PowerPoint should not be viewed as a replacement for the blackboard, but rather as an efficient auxiliary medium, otherwise, it will only serve to entertain - rather than educate - students. It seems clear that this situation must occur frequently for such disparate results to be found by multiple studies such as those discovered by Szabo and Hastings (2000) and Bartsch and Cobern (2003). PowerPoint and similar software packages do not provide the benefits to learning so often attributed to them.

While presentation software muddles the question of benefits to learning outcomes, it also unnecessarily complicates the learning process. Multimedia presentations often fall victim to a widespread practice known as 'PowerPoint abuse' (Young, 2004). The ability to create presentations does not necessarily mean that they are interesting or helpful to learning. Simply copying lecture notes into presentations without adapting or organizing them may actually diminish their value. Alison Lesht, a student at Connecticut College, expressed dislike for her professor's presentations saying, that her professor: "would write on the PowerPoint slides complete sentences, which she would then read. It didn't really add anything to the lecture. It just made everything more complicated and convoluted" (Young, 2004).

In addition to poor construction, presentations often lack interactivity. Most presentations are very static and are simply displayed without the ability to modify them easily, contrasting with overhead projector transparencies which can be easily annotated and marked up. Such changes and additions to notes or diagrams may be very helpful for illustrating points or enhancing student understanding. PowerPoint presentations offer no such convenient feature. Multimedia software presentations may be posted on class websites or course management systems. While seemingly helpful, this can reduce both attendance and focus on class materials. PowerPoint may allow students to disengage instead of becoming more engaged in the topic being covered (Young, 2004), potentially contributing to decreased classroom participation as previously discussed. Multimedia software presentations introduce additional complications to the learning process that may reduce their actual value. Like many other educational technologies, improper use will cause far more harm than good, and is usually overlooked by advocates of the technology in question.

Aside from poorly constructed presentations, technological malfunctions often prevent effective use of technology in the classroom. Wrienne T. Mitchell, a student at Ohio University, admitted that it becomes distracting when sitting in a class for only an hour, and 15 minutes of that time is spent with the professor tracking someone down to make the technology work (Young, 2004). While malfunctions do not render technology completely useless, they serve to complicate and annoy both students and instructors. Since no technology will work perfectly all the time, complexities and annoyances associated with problems are worthy of consideration. With students less interested, more distracted, and less participatory than ever before, time wasted on technological malfunctions becomes critical, and the potential burden on the classroom learning experience must be weighed against the asset value of any instructional technology.

A recurrent theme in academics is that simple things should remain simple, while accomplishable things become doable. Complexity does not always indicate a problem, but use of technology in education has clearly demonstrated a potential to inject excess and avoidable complexity into the mix. While higher education has collectively pushed an aggressive technology agenda, it seems that less concern has been given to how much student learning actually benefits from this, or that negative results are being disregarded for various reasons. While students certainly prefer technology in the classroom, it may not be providing the best learning experiences and outcomes.

Despite numerous applications where benefits are self-evident, technology is not a panacea. We now turn our attention to considerations of identifying where and how technologies should be deployed to maximize their intended benefits.

## 4. EDUCATION TECHNOLOGY BEST PRACTICES

With millions of dollars spent on high-tech campuses (Bugeja, 2007), and more people using mobile devices than ever before (Schwartz, 2003), the use of high technology in higher education is well entrenched and will not be disappearing anytime soon. Large investments and long-term commitments guarantee a technology presence. Since technology brings a host of potential benefits and potential shortfalls to the table, the best practices for the optimal use of technology will be some form of informed compromise.

The "silver bullet" technology does not and will most likely never exist. Appropriate technologies should always be drawn from a set of candidates on a contingency basis. Institutions and instructors must learn to exploit the strengths of technology while mitigating the risks. Bluntly shouldering unpopular technology out of the way may work for a time, but this will mask rather than solve the problem. A complete ban on technology in the classroom is inappropriate, and would simply result in justifiably outraged students (Read, 2006), as well as negatively affecting learning processes for which the technologies are appropriate. The proper solution requires managing technology and its risks, to maximize value added for the learning process. In order to accomplish this, certain practices and methods can be followed. We now consider selected strategies as the basis for investigation and further discussion, noting that our selections are a potentially incomplete set.

One key to using technology successfully is actually using it to solve an identifiable problem. Robert Zemsky, chairman of the Learning Alliance for Higher Education mentions that no one had identified the problem that e-learning was expected to solve. This is counter to the core principle that a problem must be identified to apply a technology solution (Bray, 2007). Technology should be used for a very specific purpose. Many technology vendors classify themselves as solution providers, but a generic "solution" in search of a "problem" may represent an even larger problem in the making. Rather than trying to replace a working model, technologies should be used to enhance existing models suffering from problems appropriate for the technologies.

As an example, Zemsky comments on the purpose and intent of the Internet as a wonderful distribution system - a communications device - not a learning device (Bray, 2007). Although the Internet may be used in learning environments, it does not make learning occur. This may make technology very useful for some environments, such as virtual classrooms which tie together physically distanced professors and students (Young, 2005), but it does not benefit all classrooms. In the case of the virtual classroom, technology solves the problem of connecting people across long distances and allowing them to communicate as if they were in close proximity. However, if they are already in close proximity, it can add layers of unnecessary procedural complexity and communications overhead, rendering the learning environment less effective.

Unfortunately, it is not easy to determine whether technology actually solves a problem. Carol Twigg from the National Center for Academic Transformation suggests that the critical idea is to figure out what techniques really do improve student learning, be they software or a particular teaching style (Young, 2005). The key to successfully integrating technology into the classroom rests upon determining the appropriateness of its presence, and the specific functions it should perform when present.

In addition to using technology to solve actual problems, institutions must be made collectively aware of when and how to appropriately utilize technology. Without such awareness, instructors will continue to waste class time fumbling with projectors or software, or devoting too much time to teaching students some quirky Web tool at the expense of delivering course material (Young, 2004). Technology training sessions for educators tend to focus on technical and mechanical aspects of the technologies rather than maximizing technological effectiveness (Young, 2004). Training would be more useful if focused on strategies which maximize technology effectiveness in the learning process. Technology by itself will not enhance learning. It must be used correctly to do so. According to Howard J. Strauss, technology-outreach coordinator at Princeton University: "what we really need instead of smart classrooms is smart teachers and smart learners" (Young, 2004). Instead of having expensive 'smart' classrooms which showcase high-tech devices, classrooms should feature minimal technology which should only be used if it actually benefits the learning process. Carol Twigg also notes that in situations where technology has been used successfully in the classroom, the key to the success of the course was the faculty members' creativity and ingenuity in the way in which they designed the learning activities for students, rather than a specific device or product (Young, 2005).

Responsibility for successful use of educational technologies rests on the shoulders of the instructor, who is ultimately accountable for learning outcomes. This reality highlights the necessity of proper awareness and understanding of technology use in the classroom. Any hope of using technology to benefit the learning process depends on organizational, as well as individual, awareness of the best ways to utilize it in the classroom. This may be accomplished through training sessions and seminars, and perhaps reducing the levels of technology present in the classroom itself.

Technology must be used at an appropriate time, for solving a real problem, and be managed by instructors. This translates to some general best practices when it comes to technology in the classroom. Among these are keeping lectures interesting and lively to combat the distractions of the technology, setting boundaries on technology use, using technology to communicate rather than teach, using technology only when it functions better than previous methods, and making the decision to cut technology when it interferes with learning. As an example, a short video presentation can be used in lieu of an entire PowerPoint lecture, to illustrate a topic.

Inappropriate techniques would include reading presentation slides verbatim, wasting time fumbling with technology instead of teaching, failing to moderate interactive classroom resources such as chat rooms, failing to set boundaries on student technology use, and using technology simply for the sake of technology. Although by no means comprehensive, these short lists should give the reader a general idea of preliminary steps to take when managing classroom technology use. The successful instructor uses technology only when it actually benefits the learning process, and will be able to mitigate the effects and risks of its use at other times.

Technology misuse can have a profound, negative effect on the learning process. However, because of its ubiquity and heavy investment, most universities and students are unlikely to forego its use. Consequently, effective technology management is needed to insure that technology adds rather than detracts value from the learning process.

Value-added technology management uses technology for solving specific problems, not simply because it has already been acquired. It applies the right tools to the right tasks, rather than attempting to shape problems to fit the tools on hand. Awareness of how to properly use technology is essential. Following certain best practices and avoiding others can be very helpful in managing technology in the classroom. In general, these will involve increasing interest in the learning material itself, while playing down technology, and ensuring that it does not distract students from the material at hand. Although institutions could ban technology, the learning process will benefit more from using it in those situations when appropriate. The error many institutions have made is to believe the fallacy that technologies are universally beneficial. The ideal solution is an enlightened compromise. This compromise mandates a better understanding of when and how to use technologies in the classroom. Student understanding of their roles in this process may increase their cooperation and the appreciation for the proper use of technology to enhance their learning experiences.

## 5. IMPLICATIONS FOR FUTURE RESEARCH

Current research lacks definitive proof that technology enhances the learning process. While the issue of whether or not technology belongs in the classroom may continue to be debated, it seems likely that it will never be absent. Therefore, additional research should focus on identifying strategies and methods that allow it to be utilized more effectively in the classroom. As previously noted, the key to successfully integrating technology into the classroom depends upon the appropriateness of its use, and the specific function it should perform. Future research should pinpoint situations where it is appropriate, and the function that it could serve in such a situation. Comparisons between current general practices, and specific strategies would be useful.

The current state of technology in education has come to pass largely due to an assumption of benefits. These assumptions have led to unrestricted and unquestioned adoption across all aspects of education, the belief that more is better. This may have occurred due to a lack of understanding or a lack of general knowledge. In order to rectify this situation, instructors should be given specific guidance on practices and strategies which provide the greatest value to student education. Workshops and seminars may be helpful in accomplishing this goal. However, the value of such efforts would be diminished without academia having a complete picture of how technology can be most effectively deployed.

## 6. CONCLUSION

Changes associated with technology in education are often assumed to be positive, and in the best interests of the student. However, there are many hidden risks associated with technology use. It would be naive to suggest that technology should be completely removed from the classroom. On the other hand, it is clear that technology must be properly managed and moderated in order to mitigate the negative aspects and bolster the positive ones. Some of the risks associated with the use of technology in education are those of decreased interest in the learning material, increased distractions, decreased classroom participation, and increased complexity of learning and teaching. Proper management and control of the technology in education can help to manage these risks. Technology should be used only when it serves a specific purpose or solves a particular problem. Simply using technology because it is 'cool' or popular results in entertainment rather than lasting educational value. Awareness of the potential problems that indiscriminate use of technology can cause in the classroom can help create a mind-set that makes technology an asset to learning rather than a liability.

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# Make it Relevant and They Just May Learn it

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## Abstract

There are many different approaches to teaching Information Systems courses. Studies have shown that if the student is interested in the topic, they just may have a more productive classroom experience. This paper documents the practice of structuring assignments around topics that are of interest to each individual student. This method has been successful in courses from the freshman level up to the doctoral level. For each of the classes described in this paper, the students are given a framework to follow for the assignments, and then asked to individualize the assignment relevant to their interests. Student attitudes toward the courses are discussed, along with recommendations for course structure and content.

**Keywords**: Information Systems Coursework, Student interest, semester project

## 1. INTRODUCTION

How do you teach an Information Systems course to students from a variety of backgrounds? (Easton 2003) How do you teach it and keep the interest of your students? Should an Introductory Information Systems course be taught differently than a doctoral level course? The first answer that one might give to this question is yes, of course. But although the course work is obviously different, the same approach for assignments can be used in almost any Information Systems course. If the course material can be made more interesting to the student, then he will be more inclined to learn it. A real world project allows the students to "learn better through a particular domain of their interest" and "see the practical value of what they learned" (Robbert 2000). The fact that students all come from different backgrounds can be seen as an advantage in any Information Systems course. Each student can bring a different perspective to the same problem that all are addressing in any particular assignment.

Large semester projects are also an important aspect of the student's course of study. The skill set required for employment in the "real world" is constantly evolving. (Gallivan, Truex & Kyasny, 2004) Coding efforts are often large projects that are completed by many individuals and comprise many lines of code. Employers want their employees to be able to successfully complete large on-going projects, as well as communicate and document their work. Programming skills along with communication skills go hand in hand for successful employment. In fact, employers are increasingly demanding this of their entry level employees (Gruba & Al-Mahmood, 2004). Thus, large semester projects along with documentation are a key element of this author's student assignments.

Researchers have investigated project-based learning in a wide variety of disciplines and settings. They have generally found it to be effective in increasing student motivation, improving student problem solving , improving higher order thinking skills, addressing different learning styles, and providing students with an integrated learning situation. (Hutchings & Wutzdorff, 1998) (Albanese & Mitchell, 1992) (Buck Institute, 1999) (Tretten, & Zachariou, 1995). Project-based learning, unlike the traditional textbook/lecture approach, motivates the student to do additional work, illustrates to the student the value of the material covered, and most importantly, provides practical experiences that enrich the student's academic growth.

Students in the courses described in this paper were given the opportunity to apply their semester projects to an area of their choice and/or interest. "Students learn about technology if they can relate it to their lives". (Hoffman & Blake, 2003)

This paper describes how an individualized student selected project approach was accomplished in the following courses:

- Introductory Information Systems Literacy (freshman level)
- C++ Programming (under graduate level)
- Database Management (senior level)
- Knowledge Management (Doctoral level)

## 2. COURSE STRUCTURE

The approach documented in this paper is one that structures course assignments according to the following:

- Semester long project is required
- A basic template for each assignment/or phase within the project is provided to the student
- The student is required to customize the assignment to an area that interests him

A summary of each of the four courses is as follows:

**Introductory Information Systems Literacy (freshman level)**

This is a required course in the code for the University and the students come from a wide range of backgrounds. According to Tsai, "it is the responsibility of the education institution to offer a computer literacy class or series of classes for preparing its students with proper computer knowledge in a suitable learning environment before they enter the business world". (Tsai, 2002) The fact that students all come from different backgrounds and majors is seen as an advantage by this author. The students bring a wide view of the basic topics by applying the assignments to an area of their choice. A greater challenge is to "design IS courses for students who have no intention of pursuing the vigorous IS professional training". (Law, 2003) However, The National Association of Colleges and Employers reported that employers are looking for employees with computer skills even in non-related positions. (http://www.naceweb.org) Therefore, this course could help to make the student more marketable in his job search. Also, allowing flexibility with this course is seen in a very positive light among other departments on Campus. (Learmonth 2001)

Information Systems topics were introduced to the student with his major or area of interest in mind. The student was asked to pick an organization to model throughout the entire semester. The choice of the organization related to the student's major or some other area of interest to the student. The organization was used by the student as the framework for all assignments during the semester.

This course was to teach Information Systems concepts as well as the application software, Microsoft Excel and Access. The approach taken for instruction in the classroom varied according to the topic being covered. In the case of Excel and Access, skills were taught before the assignments were given. As to the information system concepts, there was first a discussion of the particular topic in class. Next, the student researched the topic as it related to his organization. The student then reported his findings to the rest of the class. These oral reports were both formal with the use of Power Point, and informal in nature

Some examples of the organizations chosen by the students were:

- KDKA Pittsburgh Television Station – Student was a media arts major and had an internship with the station
- Restaurant – Student was a business major and had a job at the restaurant
- Hardware Store – Student was a business major and his parents owned the Store
- Insurance Firm – Student was a business major
- Elementary School – Student was a education major
- Law Firm – Student was a pre-law major
- Brokerage Firm – Student was an Economics major
- Hospital – Student was a Health Care Information Systems major

**Initial Profile Project Assignment**

The student chose some business or organization that he modeled for the semester. This could be a fictitious business or organization or it might be a real one in which the student may or may not have been involved. Any financial data provided during the semester was to be simulated. The business/organization must meet the following requirements:

- It has employees
- It offers a service or produces a product
- It has a variety of financial needs

The student then created a profile of the business/organization. The following elements of the business/organization were addressed in the profile:

- Name and location
- Purpose
- Mission statement
- Number of employees
- Location of employees (business may have more than one site)
- Summary of various financial needs

**Spreadsheet Examples Assignment**

The student was asked to create five spreadsheets that are related to tasks that might need to be completed for their organization. One of the spreadsheets was to be a payroll register. The other four spreadsheets were of the student's choice. All of the spreadsheets were to be done in a professional manner (margins, headings etc…) At least one of the spreadsheets was to have a chart (graph) using some of the data.

**Software Selection Assignment**

In this phase of the semester project, the student investigated software appropriate to their organization. They then made a recommendation as to what software package should be purchased to support the major function or functions of the organization. In making the recommendation, they were to compare at least two software packages in terms of features, hardware requirements, price, limitations, etc. Based upon the findings, the student made a recommendation as to what should be purchased. They provided all supporting documentation and a plan for implementation of the software, including installation, training, and data transfer.

The student then made a formal presentation to their boss (the class) summarizing their recommendation.

**Intranet Assignment**

Each student set up an Intranet site for their organization with many required elements such as tasks, polls, databases and linked documents. They then wrote a paper summarizing the value of an intranet to their organization.

**Database Assignment**

The student created a database to store employee information of their organization. The required information for the organization included areas such as payroll, scheduling, and human resources evaluation data. The project was completed in Access and included all the tasks required to define the necessary tables, forms, queries and reports. The students were given specific queries and reports to perform relevant to their specific organization's database. They were also required to write a user's guide for the database.

**Introductory Information Systems Literacy Course Summary**

While the course was taught in the individualized format presented here, another regular section of the course was run where students followed a prescribed outline of the course work as defined in the textbook. All assignments were taken from the book and students were given multiple choice tests from the publisher. Students from both sections were surveyed at the beginning and the end of the course. They were asked about their knowledge of Computer Information Systems in general and spreadsheet and database work specifically. In those three areas, the students in the individualized section of the course reported that they learned more than the students in the regular section.

Seventy four percent of the students in the individualized section felt that the course was somewhat challenging as opposed to 38% of the students in the regular section. Students need to be challenged. Research has shown that this can be an essential part of the learning process (Martin, Hands, Lancaster, Trytten & Murphy, 2008).

Students in the individualized section of the course reported that they did spent more time working on the course material than did the regular section. Perhaps this is because they were more interested in the course content? (Hoffman & Blake 2003)

The individualized section reported a higher enjoyment level than the regular section.

Although this is not a critical element of the analysis of the course structure, it makes the course a bit easier to teach and somewhat more rewarding to the author.

**C++Programming Course (undergraduate level)**

Ninety percent of the students in this course had no programming background, with this being their first coding course. Therefore, a few small programs were first required in order to teach some very beginning tasks, such as assignment statements, if statements and loops. The semester project was assigned to students at week four in the fifteen week semester. Since these students were beginning programmers, it was a challenge to this author to come up with a project that allowed the students to choose their on area of interest, and thus create their own data set.

**C++ Project**

Students wrote a menu driven program that was broken up into phases. At the completion of the project, each student's project performed the following tasks utilizing the data of the students choice:

- Read data from data files
- Wrote data to data files
- Implemented various class structures
- Manipulated data in multi-dimensional arrays, including inserting, deleting and modifying
- Coded various error checking functions
- Coded various search functions
- Coded reports
- Wrote user's and programmer's guides for the project

**C++Course Summary**

At the completion of this course, students reported that they were very proud of the large coding project they had written. Again, most of them had no previous programming experience. A number of the students said that they spent a great deal of time on the project, but because of the individualized data, the extra time was something they did not mind. They reported that they felt that the project was more interesting to work on because of the data being of interest to them. This author has taught beginning programming for many years, and always included a large project such as this one. But this is the first time that each student designed their own data set. Success was achieved from both types of projects, this individualized type and the projects in which all students manipulated exactly the same data set. But it must be noted that the students who defined their own data completed additional functionality in their code beyond what was required.

**Database Management (Senior level)**

Most students in this course are seniors and applying the topics to their area of interest should not be a problem. In fact a database project does lend itself to easy individualism. But what was not expected was the fact that many of the students went well beyond what was required in the database project. They reported that they just could not "put down" the project.

Initially the students were to come up with a real world database project that could be completed in a 15 week semester. The students were asked the following questions about their proposed database project:

- What is the central focus of the database?
- Why was this topic selected?
- What kinds of things will this database be able to do?
- What kinds of information will the database provide for the user?

**Database Phase I Requirements**

- All tables are to be defined (keys, constrains, etc…)
- All input forms for the tables are to be completed.
- At least one sub form must be present
- All forms are to have the same "professional look"
- All forms are to have a header area
- A main form must be present to link all other forms
- Descriptive names are to be used for all field names on the forms
- Two types of forms are to be represented (column and tabular)
- Buttons must be present on all forms to control input (add, delete, save, etc..)
- At least three pull down lists must be present
- All forms are to have close and search buttons
- Relationship screen must be completed
- records must be entered in each table

**Phase II Requirements**

- Create at least 8 reports
- Add functions to at least two of the reports (sum, count etc.)

- Create a form with buttons on it for all of the reports
- Create at least one update query that will be run from a button on a form.
- Create at least one delete query that will be run from a button on a form.
- Create a macro that will be run from a button on a form
- Create a pop up form showing information of the student's choice
- Define a form that automatically opens when the database starts
- Add an option box to one of the forms
- Make sure that at least one of the forms comes from a query
- Create a query screen containing data in a tabular format that allows the user to do custom searches. Create a button to access this screen
- Create a user's guide and a programmer's guide

**Database Course Summary**
The database students far exceeded the author's expectations in terms of the quality of the projects. Because the students were creating real projects for real users, getting it "right" was essential. This does add a great deal of extra work for the instructor. But the reward of seeing the student's success far outweighs the additional time spend. The students were excited about the work and related that in class on a daily basis.

It must be noted that there were other section of the database course offered in which students created exactly the same project (same table structures, queries, etc.) Although there was no significant difference in student grades, there was a significant difference in the excitement in the classroom. A number of students who created the individualized project reported that they intended to specialize in database work in the future.

**Knowledge Management (Doctoral level)**
Allowing students in this course to apply their assignments to an area of their choice was quite simple. All of the students were working professionals and were able to focus on an organization of which they were currently or previously employed. This was an excellent teaching opportunity. The concepts of Knowledge Management were applied by each student in a very different area using many different techniques. With each phase of the semester project, the students reported their particular organization's challenges as they related to the required Knowledge Management tasks. The project assigned is as follows:

**Phase I**
The student performed a knowledge based SWOT analysis of their organization. Students were asked to define the business strategy their organization maintains and how it was aligned, if at all, with knowledge management?
The summary of the SWOT analysis is as follows:

- Strengths - What is done well?
- Weaknesses - What needs to be improved upon?
- Opportunities - What opportunities are being missed because of poor knowledge management?
- Threats - What are the threats if conditions are not improved?

The student was also to write a short summary of the technology that existed in their organization.

**Phase II**
The student performed a Knowledge Audit on the area of their organization that was defined in phase I.

The steps of the knowledge audit were as follows:

- Define Goals
- Identify Constraints
- Determine the Ideal State
- Select the Audit Method
- Perform the Audit
- Document the Audit

The student was to summarize what was going well, what needed to be done better and why, and what technology might be applicable to support on going and new knowledge management initiatives

**Phase III**
The student was to create a blueprint for solving the knowledge management issues that arose in the knowledge audit. They were to map out what direction they would take to make knowledge creation, sharing, etc. better.

- What steps would be taken to promote knowledge sharing?
- What hardware and software would be implemented? (what is already there or what must be purchased)
- What cultural issues must be dealt with?

- What is the makeup of the knowledge management team?
- What measurement will be used to determine the success of the knowledge management initiative?

**Knowledge Management Course Summary**
This course design proved to be very successful. In most cases, the students reported many of their findings to their superiors and their peers at their place of employment. In a number of cases, this lead to actual knowledge management initiatives being instituted in the student's organization. These were doctoral students and one would expect a high interest level in the topics, but the excitement that was generated when each gave their final presentations, was not expected. This was extremely rewarding for this author.

## 3. CONCLUSION

There are many right ways to teach Information Systems courses. Designing a semester project that is relevant to the student has been extremely successful in the courses referenced in this paper. Students were very proud of their results and often went well beyond what was required in the project.

The students were happy to apply the technology to what interested them. One of the drawbacks to this approach is that because of the instructor's individual time given to each student's project, it could limit the topics that can be covered.

Support for faculty is one issue that has not been addressed in this paper and must not be ignored. Although it is not a conclusion, it is a recommendation that institutions must provide support for those instructors who are willing to spend the additional time needed to work with students who are all each creating a different project. This support could be in the form of controlling class size and limited course preparations. If the support is not there, the success of any such course can not be assured. (Gopalakrishnan, 2006)

Those teaching a course such as this must be very organized and attentive to the students. A policy of answering the student's email within 24 hours is extremely important. Students need to feel that the instructor is accessible. A study done by Yang and Cornelius also supports the concept that the students must receive feedback on a timely basis. (Yang, 2004) Help was available and given when needed. One student in the database class said; "Without a doubt this was one of the best classes I have ever taken. The teacher was readily available; she responded to my emails fast."

Information Systems are in every phase of our lives. The students need to see that this is the case. The approach described in this paper can be used for almost any Information Systems course and thus help to promote the "IS" area of study while keeping the interest of the students. This author's experience has shown that when the student is interested, he will work harder and perhaps learn more.

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# An Improved Database System for Program Assessment

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## Abstract

This research paper presents a database management system for tracking course assessment data and reporting related outcomes for program assessment. It improves on a database system previously presented by the authors and in use for two years. The database system presented is specific to assessment for ABET (Accreditation Board for Engineering and Technology) accreditation effort of a CIS (Computer Information Systems) department, but could be easily adapted to any program assessment. The relevance of tracking course assessment data and its role in reporting the outcomes for assessment is discussed. Issues of consistency, efficiency, flexibility, and reusability are discussed and sample data and reports are presented. This paper concludes with a discussion of the merits of the database management system as a tool in program assessment.

**Keywords:** program assessment, ABET accreditation, course assessment, database system

## 1. INTRODUCTION

Program assessment has become one of the highest priorities in higher education and a key component of accreditation efforts for any academic program. Program review and accreditation efforts for organizations such as ABET and AACSB require the tracking of data from

such sources as questionnaires from alumni and feedback from advisory boards. Another key ingredient for assessing program outcomes is the performance of students in the required coursework in the program. Outcomes of any instrument used to evaluate student performance, such as homework, projects, presentations, course exams, and national exams, can be used for course or program assessment. Course objectives can be evaluated using objective measures and this data can be aggregated to assess the program outcomes. To support the gathering and analysis of this data, a relational database was designed and implemented in Microsoft Access. This paper describes the mapping of course learning objectives for a CIS department's courses to both the program outcomes and ABET outcomes, the development of a relational database to support the assessment of courses, and an ongoing evolution of that database system.

## 2. LITERATURE REVIEW

A review of the literature shows that while there is a wealth of research on the general topic of program assessment, there has been a relatively limited number of efforts to develop tools and software to help streamline the time-consuming and burdensome process of data collection and analysis for program assessment.

Spurlin reports on the development of a database for collection and analysis of data of an engineering program for ABET accreditation (Spurlin, Rajala, Lavelle, & Hoskins, 2002). However, it is not clear if the system allows for easy input of data from exams and projects and easy generation of assessment reports. Harding (2005) reports on the development of a prototype web-based assessment system for an ABET accredited engineering program. The author indicates that the student developed prototype had a number of problems but provides a good base to build upon.

Poger describes a web-based system developed for online evaluation of courses for a Computer Science department (Poger, Kamari, Chuah, & Ricardo, 2005). The system is used to compile data from student prerequisite skills surveys, course objective student surveys, faculty course objectives assessment, and student exit surveys.

Booth proposes a database template that, among other things, provides a mechanism to map program outcomes and course objectives to ABET outcomes (Booth, Preston, & Qu, 2007a). Booth also proposes requiring students to submit assignments via the Web and a method for extracting assessment metadata from these assignments. Booth presents a prototype of the implementation of the template in a second paper (Booth, Preston, & Qu, 2007b).

Urban-Lurain proposes a database system that includes a newly defined extensible Educational Metadata Language- EdML(Urban-Lurain, Ebert-May, Momsen, McFall, Jones, Leinfelder, & Sticklen, 2009). EdML enables assessments to be tagged based on taxonomies, psychometrics, and other data to facilitate analysis.

Segall presents a database driven system for IS Curriculum Assessment using the national ISA exam (Segall, Ghosh, & Morrell, 2009). The system provides for two-step mapping from ISA exam questions to course objectives via the 2002 IS Model curriculum Learning Units (LU).

Essa (2010) proposes the ABET Course Assessment Tool (ACAT) as his Masters thesis. ACAT is a web-based tool that allows Faculty to input assessment data and generate a report in pdf format. This work appears to take a similar approach to the database design taken by Morrell (Morrell, Morris, & Haga, 2009).

## 3. BACKGROUND

The CIS Department faculty at Metropolitan State College of Denver debated for months before finally agreeing on a set of program outcomes prior to the initial pursuit of ABET accreditation. The final result was a set of 10 program outcomes, which are listed in Table 1. Subsequently, many additional months were spent mapping: 1) CIS course learning objectives to these CIS Department outcomes; and 2) CIS course learning objectives to the 10 ABET outcomes. The ABET outcomes are listed in Table 2.

This work was performed by a CIS Department taskforce. During these meetings, a faculty member came up with the idea of developing a database management system to record and analyze assessment data for courses. A collaborative process lead to the design of this relational database.

The goals for this database design were as follows:

a) The design must be sufficiently flexible to allow tracking of any instrument used in evaluating students while allowing the faculty to determine the scale and level of the items measured.

b) The design must provide for a control of consistency of the data captured.

c) The design must provide a mechanism for mapping the course evaluations to program and ABET outcomes.

d) The design must be portable and reusable for subsequent accrediting efforts.

e) The data entry for the system must be sufficiently utilitarian to be acceptable by faculty and staff.

## 4. DBMS DEVELOPMENT

### Initial Database Design and Implementation

The initial database design was previously presented by Morrell at the Northeast American Society of Engineering Education (Morrell, 2009).

The Entity Relationship Diagram (ERD) for the improved database design is shown in Figure 1***.*** The database entities are explained in Table 3. Looking at the design we can see the tables that relate to the two mapping processes described above. The mapping of CIS course objectives to the CIS Program Outcomes is handled by the *CourseObjective*, *Po_Co*, and *Program_Outcomes* tables. The mapping of CIS course objectives to the ABET Outcomes is addressed by the *Course_Objective*, *Ao_Co*, and *Abet_Outcomes* tables. The basic *Course*, *Faculty*, and *Class* data was imported from the college scheduling system.

The assessment instruments, such as exams, quizzes, assignments, and projects were entered into the Eval_Instrument table. To facilitate access for faculty and staff, the database is stored on a network shared folder. Faculty have access to this folder and the Information Technology department configured access for an administrative assistant. Faculty can enter the data themselves or record the data on a paper form. The data from the latter can then be entered by an administrative assistant.

After the assessment instruments are entered, faculty can enter evaluation items for each instrument. In terms of tracking students' success, a faculty member can choose one multiple choice question, a group of multiple choice questions, a short answer question, a whole project or part of one. In other words, the faculty member has total control over the granularity they use.

Before any data is captured the Department must set up guidelines for entering the results of any item on any instrument. An example would be the *countright* attribute in the database – see Figure 1. If the instrument is an exam and the item is a subjective question, then the department must decide what "*countright*" means. The department agreed that a passing grade means that the student scored a seventy percent on that item. For multiple choice questions, the determination of passing is clear, but for subjective items, the seventy percent measure is used.

The class entity includes time attributes, which will allow for periodic review, analysis, and comparisons over any number of semesters/years. The database could also be easily modified to track curriculum changes and their effect on student outcome scores.

### Sample Database Form and Report

A data entry form (see Figure 2) is used to facilitate data entry of the detailed assessment data. It also promotes consistency and accuracy.

This form allows users to enter assessment data for each evaluation item (e.g. question 11) for each evaluation instrument (e.g. an exam). Therefore this form corresponds to the Eval_Instrument and Eval_Outcome tables (see Figure 1). The user first selects a class ID (CRN) from a drop-down box and information about this class is displayed so the user knows they are entering data for the correct class. They then enter the data for exams/projects as well as how many students were successful on the chosen questions.

The data entry form emphasizes the granularity possible with this design. Looking at the bottom part of the form a faculty member can enter an Eval_ID of *E1* for Exam 1 and then enter every question on that exam as an evaluation item. Entering each question as an evaluation item would only make sense if these questions can be mapped to the course and ABET objectives. Alternatively they could group five questions that pertain to one course objective and enter this as one row in the form.

The *CIS Assessment Data by ABET Outcomes* report (see Figure 3) displays the detailed assessment data grouped by ABET outcomes a–h. Each outcome has a list of all courses, evaluation instruments, as well as the success rate for each evaluation item that pertains to that outcome. The *Percent* column indicates the percentage of students in a class who got a question correct.

### Second Database Design and Implementation

The initial database system was used for one year and the information generated was used in the creation of the Self-Study report for ABET accreditation. After having had a year's experience with the database management system, faculty expressed a few concerns:

a) Regardless of whether an assessment item was a multiple choice question, an essay question, a minor homework assignment, or even a major project there was no way to "weight" the item – so for example a multiple choice questions was being counted as equal to a major project.

b) There was no distinction between a lower level objective such as "Identify the components of a LAN" and a higher level objective such as design a LAN/WAN network.

c) Faculty had trouble remembering what the assessment items were when reviewing reports later.

This lead to the following modifications to the database:

***Weight*** is added to the Eval_Outcome table. This allows a professor to distinguish between the various types of exam questions (true/false, multiple choice, fill-in the blank, short answer, essay, program, coding, design problems, etc) and the various types of homework assignments (research papers, programming assignments, minor projects, major projects, etc). For example in the case of a database course, it is clear that a multiple choice question on an exam should not be weighted the same as a problem that requires students to create an ERD from a set of several business rules. The ERD should have a much higher weight than the multiple choice question when it comes to determining if the course objective, and therefore a program outcome, is met. An example of weighting for such a class, a multiple choice question could be assigned a weight of 1, a short answer question a weight of 3, and ERD a weight of 5 and a major project a weight of 10.

***BloomLevel*** is added to both the Course_Objective and Eval_Outcome tables. When developing/modifying course learning objectives, faculty frequently use the Bloom levels. In fact, the college-wide Curriculum Committee for this college checks these objectives using Bloom levels. Adding the attribute to the Eval_Outcome table allows faculty to match evaluation items with the learning objectives in the course syllabus. It could also be used by the course coordinator and/or curriculum committee when reviewing assessment to identify possible problem areas (i.e. Faculty trying to measure higher level objectives with all multiple choice questions).

***ItemType*** is added to the Eval_Outcome table. It allows faculty to indicate the type of evaluations item, such as multiple choice question, short answer question, assignment, etc. This is helpful when reviewing the assessment data at the end of a semester.

***ItemDesc*** is added to the Eval_Outcome table. It allows faculty to indicate the concept/skill covered by the evaluations item. Using the database class example again, while *ItemType* could indicate a multiple choice question, *ItemDesc* for example could tell us that it was a question related to foreign keys. This is helpful when reviewing the assessment data at the end of a semester. Otherwise the faculty member has to go back to the evaluation instrument, say an exam, and find the question to which this item pertains.

## 5. DISCUSSION

The initial database design in this paper was adopted by the authors' CIS Department and has now been used for 4 semesters.

Dr. Janos Fustos, Chair of the department's ABET committee, provides the following evaluation of the database system:

> Being charged to coordinate the CIS program's ABET activities, I appreciate your work that provides us with this important tool. As accreditation agencies have moved to an outcome oriented program assessment it is vital for us to have a data source that records all the assessment activities and data that we can use to evaluate how far our program meets the aimed goals and criteria proposed by accreditation requirements. The database system that you've created allows us to capture the necessary data, generate reports at different granularity levels, and supports all of our documentation requirements including course revisions, curriculum modifications, annual analysis, regional and professional accreditation, and periodical program reviews.

Course coordinators are required to, and responsible for, entering assessment data for their courses in the database each semester. The database system and its results, along with specific ways the system help to improve courses, was presented to the ABET Visiting Team in the Fall of 2009. The team responded with very positive feedback. In addition, other departments seeking accreditation at the college have expressed a desire to have access to the database system. The reaccreditation process was successful. In fact, the department received an Assessment Achievement Award for its diligence in identifying course-embedded sources of evidence, articulating targets for student scores on program outcomes data, and engagement of the faculty. The award was accompanied by a monetary prize. Therefore the authors believe this bottom-up approach of assessing student performance in CIS courses played an important role in successful reaccreditation. This information was used in the creation of the ABET Self-Study Report. However, the system is much more flexible and adaptable than just this particular application. Indeed these are key characteristics of the design. The system could be used not just for ABET accreditation but also any other academic accreditation effort such as AACSB. In addition it could be used by any non-academic organization that captures numeric data for assessment

Another strength of the design is that the expert, say a course coordinator, is in control of the chosen granularity. They can choose whether they want to track individual multiple choice questions, a group of multiple choice questions, a complete project, or a part thereof. In addition to the choice of granularity, an organization can choose which attributes to use. For example, they could initially choose to ignore *Weight* and *BloomLevel*. If necessary they could start capturing these items in later time periods. This flexibility reduces the barriers for the adoption and use of an assessment tracking system.

The organization also decides how to handle such issues as what percentage constitutes passing a subjective evaluation item such as a short answer question. This department uses greater than or equal to 70% as a passing score and then counts the number of students that got this score. Another organization could choose a different value.

How can the information from the generated reports be used? An example from a LAN/WAN class illustrates the potential. The faculty member noted from the reports that students answered a question about routing and autonomous systems poorly. More emphasis was given to this material in the following semester with a resulting improvement in student results. Thus one key application of the system is to identify weaknesses in the coverage of the subject matter and to be able to address these issues in subsequent semesters.

Another example of the use of the information captured by the system is the identification of anomalies. For example, a course may have a certain Bloom level but there are no evaluation items at this Bloom's level. The department could then evaluate how to improve assessing the students in this course. This illustrates the potential of the system to be used for addressing continuous improvement.

In conclusion, the database design allows the tracking of course results at any level of granularity. If a department is in doubt about the level of detail required, the database can store all the items of all instruments used to determine course or program results. This is important to programs that undergo accrediting for multiple agencies such as ABET and AACSB. The mantra for this system is "If the data is sufficiently captured and organized, any reporting requirement on program results can be met". Hence the Department must invest the time and effort in developing the requirements for collecting the data.

## 6. SUMMARY AND cONCLUSION

Program assessment is now one of the highest priorities in higher education and has a vital role in program accreditation. Course assessment, which is an important focus in program assessment, is centered on collecting and reporting data related to course outcomes. Although there are various approaches to the latter task, this paper presents a system which is DBMS centered to accomplish this task. The system described in this paper is one that addresses the issues of consistency, flexibility, reliability, and reusability. The discussions above make a case that the system is technically and operationally feasible and that it meets criteria developed by the department for program assessment. The discussion of the evolution of the systems reveals the critical element of involvement of program constituents and the flexibility and utility of the system. Although the system was developed for a specific program for accreditation, it has the potential to be used by any similar organization (program or department) undergoing assessment for any purpose such as accreditation by agencies including ABET or AACSB. While the system is designed to be used primarily for tracking class assessment data, it can be modified or adopted for tracking any quantitative metric used in assessment of an organization by an agency. The overall goal of such a system is to simplify, standardize, and organize the capture of data to provide a rich repository to support current and future assessment efforts. The system described in this paper meets that goal.

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## Appendix

### Table 1 - CIS Program Outcomes

The program enables students to achieve (by the time of graduation) the following outcomes within the framework of professionally accepted Information Systems practices:

| | |
|---|---|
| SO1: | Knowledge of basic information systems theory and concepts and the skills to apply this knowledge to the functional areas of business |
| SO2: | Knowledge of project management tools and techniques as they apply to Information Systems projects |
| SO3: | Knowledge of programming processes including planning, writing, testing, executing and debugging |
| SO4: | Knowledge of database design, development and management |
| SO5: | Knowledge of telecommunications and networking systems |
| SO6: | Knowledge of web-based systems |
| SO7: | Knowledge of operating systems |
| SO8: | Knowledge of how to create and utilize team approaches to problem solving |
| SO9: | Advanced knowledge in an IS area |
| SO10: | Ability to support the delivery and management of information systems |

**Table 2 - ABET Outcomes**

The program enables students to achieve, by the time of graduation:

| | |
|---|---|
| : | An ability to apply knowledge of computing and mathematics appropriate to the discipline; |
| : | An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution; |
| : | An ability to design, implement and evaluate a computer-based system, process, component, or program to meet desired needs; |
| : | An ability to function effectively on teams to accomplish a common goal; |
| : | An understanding of professional, ethical, legal, security, and social issues and responsibilities; |
| : | An ability to communicate effectively with a range of audiences; |
| : | An ability to analyze the local and global impact of computing on individuals, organizations and society; |
| : | Recognition of the need for, and an ability to engage in, continuing professional development; |
| : | An ability to use current techniques, skills, and tools necessary for computing practices. |
| : | An understanding of processes that support the delivery and management of information systems within a specific application environment. |

**Figure 1 – Database Design**

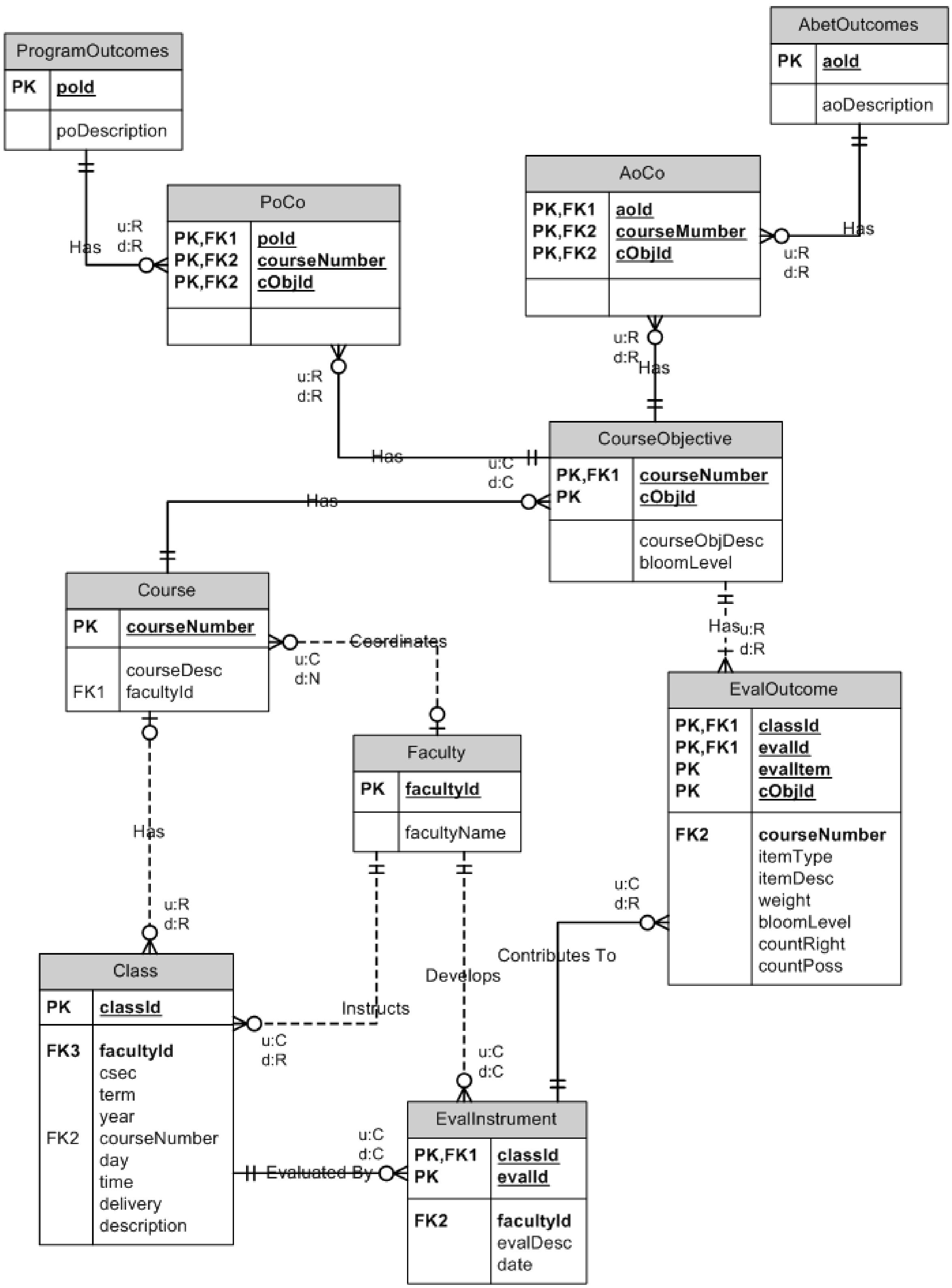


**Table 3 – Database Entities**

| ***Entities*** | ***Description*** |
|---|---|
| ABET_OUTCOMES | *All ABET outcomes.* |
| AO_CO | *Maps course objectives to ABET outcomes.* |
| CLASS | *Specific information for a given section offering of a course* |
| COURSE | *General information about each Course* |
| COURSE_OBJECTIVE | *All course objectives for a course* |
| EVAL_OUTCOME | *Individual items from a specific evaluation instrument* |
| EVALUATION_INSTRUMENT | *General information about a specific assessment* |
| FACULTY | *General information about the faculty member.* |
| PO_CO | *Maps course objectives to program outcomes.* |
| PROGRAM_OUTCOMES | *All program outcomes for the CIS degree.* |

**Figure 2 – Data Entry Form**

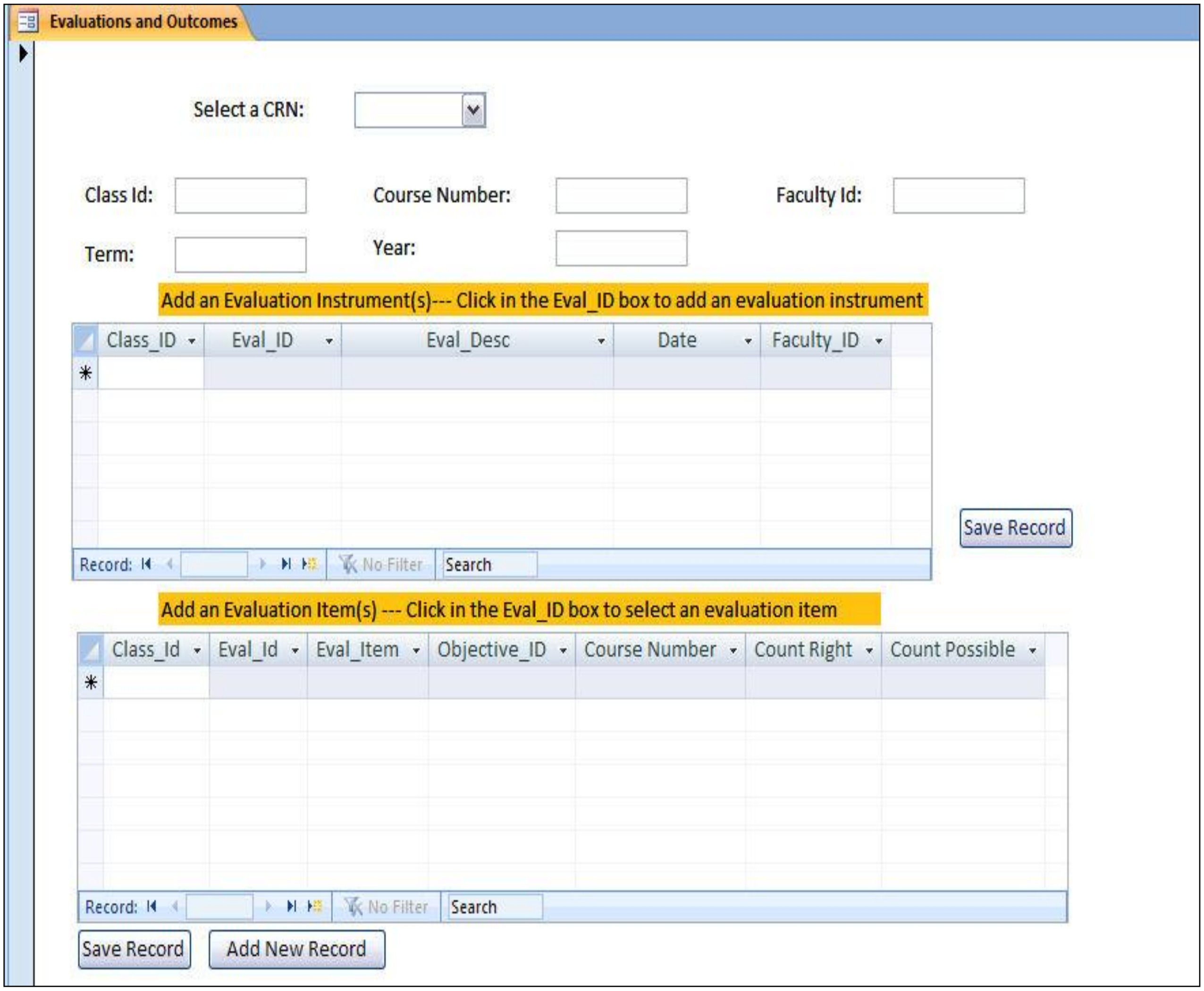

**Figure 3 – Reporting Assessment Data by ABET Outcome**

**CIS Assessment Data by ABET Outcomes**

| ABET Outcome | Course Number | Course Objective # | Course Objective | Evaluation Item | Percent |
|---|---|---|---|---|---|
| **a** | **An ability to apply knowledge of computing and mathematics appropriate to the discipline;** | | | | |
| | 3030 | 6 | Search for and use Web development resources | Discuss2 | 75.00% |
| | 3030 | 6 | Search for and use Web development resources | Topic2 | 80.00% |
| | 3030 | 6 | Search for and use Web development resources | Topic1 | 85.00% |
| | 3030 | 6 | Search for and use Web development resources | Search | 90.00% |
| **b** | **An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution;** | | | | |
| | 3030 | 2 | Develop Web site specifications for any kind of Web site from a set of requirements | q39 | 94.74% |
| | 3030 | 2 | Develop Web site specifications for any kind of Web site from a set of requirements | q15 | 95.00% |
| | 3030 | 2 | Develop Web site specifications for any kind of Web site from a set of requirements | q50 | 100.00% |
| | 3030 | 2 | Develop Web site specifications for any kind of Web site from a set of requirements | q49 | 94.74% |
| | 3030 | 2 | Develop Web site specifications for any kind of Web site from a set of | q48 | 84.21% |

# Implementing a Dynamic Database-Driven Course Using LAMP

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## Abstract

This paper documents the formulation of a database driven open source architecture web development course. The design of a web-based curriculum faces many challenges: a) relative emphasis of client and server-side technologies, b) choice of a server-side language, and c) the cost and efficient delivery of a dynamic web development, database-driven platform. This paper reviews alternative dynamic web development, database-driven platforms and presents a case study of integrating LAMP, an open source dynamic web data-base driven solution, in an Information Systems Curriculum. Three sections were presented over a three-year period. Information concerning course content, instructional delivery methods, alternative LAMP technological infrastructures, student retention and performance are also discussed.

**Keywords:** LAMP, WAMP, PHP, Apache, MySQL, Dynamic web pages, Open source, Web development, Database-driven web sites

## 1. INTRODUCTION

In response to the high demand from industry, teaching web development and programming has become an important component of the CS/IS curriculum (Wang, 2009.) Janicki, Gkowen, Kline, & Konopaske (2004) conducted an exploratory survey which provided evidence that employers are increasingly interested in both proprietary and open-source dynamic, database-driven web development skills. Employers indicated that skills with Windows or Linux, VB.NET/ASP.NET and SQL Server were desirous. The study further indicated programming skills for entry-level hires remains at a high level as compared to their previous surveys.

The design of IS web-based curriculum faces several challenges. These design challenges include: a) relative emphasis of client and server-side technologies, b) choice of a server-side language, and c) the cost and efficient delivery of a dynamic web development, database-driven platform. This paper reviews alternative dynamic web development, database-driven platforms and presents a case study of integrating LAMP in an Information Systems Curriculum. The results of alternative LAMP technological infrastructures, instructional delivery methods, and student retention and performance were analyzed and discussed.

## 2. BACKGROUND AND RELEVANT LITERATURE

### Web Based Curriculum

Perry (2002) listed several components necessary to support a dynamic, database-driven (DDD) web site. A dynamic website has five major platform components: the operating system, the web server, the application server, the database and the programming/script language. Markup or programming languages represent only one component that is required to support a dynamic, database-driven website.

Chung & McClane (2002) listed a diverse selection of languages that serve as a basis for web-based curricula. These languages include: markup languages ((X)HTML and XML), style sheet languages (CSS, XSL), client-side languages (JavaScript), server-side embedded languages (PHP, JSP, ASP, CFML), and server-side high-level languages (Java, ASP.NET). This list illustrates the number of infrastructure tiers and alternative languages which increases the complexity of designing a web-based curriculum.

Chung & McClane's (2002) case study was based on a course that included various client-side technologies and server-side Java and JavaBeans applications. Their conclusion was that their approach was successful because: a) many students had a first-level program language course in Java, b) the low cost of open source software, c) and students were able to install and administer their enterprise environment. On the other hand, the Chung & McClane study (2002) also reported challenges for student's access to lab computers, lack of documentation, and extra work for the instructors.

A variety of dynamic, database-driven platform solutions exist to support E-Commerce and Content Management System (CMS) web sites. Frequent comparisons are made between two popular dynamic web platforms: LAMP (Linux, Apache, MySQL, and PHP) and WISA (Windows, IIS, SQL Server, and ASP.NET) (Perry, 2002, Web Master Tips, 2006.) Other solutions have included other dynamic program/script languages, e.g., Java, Java Server Pages (JSP), and Cold Fusion Markup Language (CFML), Database Management Systems, e.g., PostgresSQL, Oracle, DB2, and Application Servers, e.g. Tomcat, JBOSS, WebLogic, and WebSphere.

Within the structure of a DDD platform there is also a need to distinguish between HTTP web servers and application servers. Web servers support delivery of static web page content using the HTTP protocol. Examples of HTTP web servers include Apache and IIS. On the other hand, application servers will provide an environment that will execute server-side applications and provide database connectivity to a data base management system. Apache and IIS can load additional modules that provided the application server function. Other application servers are independent of the web server, e.g., JBOSS, Tomcat, etc. Application servers and dynamic server-side programming languages are at the core of dynamic, database-driven web sites.

While there may exist many newer and easier-to-use dynamic web platforms, e.g., Ruby on Rails, ASP.NET and J2EE, the popularity of LAMP continues to grow (Learn Computer, 2010.) Builtwith.com (2010) reported that PHP was in active use by more than 2.9 million web sites and 33% of the top one million active web sites. Apache was the most popular web server representing 55.8% of all public web servers. In 2008 then over 11,700 registered PHP projects listed on SourceForge.net and other high-profile applications like Face Book and Wikipedia (Cholakov, 2008).

### Using Lamp as a Dynamic, Database Driven Platform

There are many reasons why open source software is popular. According to the Open Source Initiative (2010), "Open source is a development method for software that harnesses the power of distributed peer review and transparency of process. The promise of open source is better quality, higher reliability, more flexibility, lower cost, and an end to predatory vendor lock-in." Dionisio, Dickson, August, Dorin, & Toal (2007) proposed that the characteristics of the Open Source Culture should be reflected in the teaching framework presented in all four years of an undergraduate, computer science curriculum. Several sources have listed the advantages of using LAMP and open source software as follows:

- Open Source Licensing (no cost) or Large Scale Commercial License Alternatives (Scalability)

- Non-proprietary. User communities set development goals and provide free support. Faster feature development
- Popularity and Wide Deployment
- PHP is easier to learn than Java, Java Server Pages, and ASP.NET
- PHP can be coded in either a procedural or object-oriented style.
- PHP can be used on a variety of operating system platforms and web server (cross-platform compatibility )
- PHP is faster than other scripting languages, EJB, Java Servlets and comparable to ASP.NET. Differences in Java performance decreases in three-tier environment.
- PHP, Linux, Apache and MySQL tend to be very stable and do not change radically between versions.
- PHP supports a wide variety of standard and object-oriented databases.
- MySQL supports stored procedures and triggers
- Since PHP may be hard-coded rather than generated by a WYSIWYG editor, better code may be created.

(Converse & Park, 2004, Web Master Tips, 2006, Learn Computer, 2010. My Solutions, 2009, Misfit Greek, 2010, Sheldon & Moes, 2005)

Open source versions of LAMP may provide a practical way for students to experience open software within the curriculum. However, one must be careful to distinguish that LAMP is both an open source platform and also widely available as proprietary platform from Red Hat, IBM and other vendors. Several sources have presented some of the disadvantages of PHP as a programming language:

- PHP variables are loosely typed, which can lead to some problems that are difficult to detect.
- Inconsistent case rules: PHP variable names are case-sensitive while function name are not.
- Global variables may be changed by hackers in the HTTP header.
- PHP does not require modular or object-oriented programming, which can lead to poor programming techniques.
- While PHP code may be compiled, there is no support for multithreaded operations or asynchronous execution
- Exception handling was only introduced in later versions and is not backward compatible
- Scalable options, e.g., clustering, replication of distributed databases, partitioning, failover, etc. are only available at a cost using proprietary versions, e.g., Red Hat Enterprise Linux, MySQL AB

(Web Master Tips, 2006, Cholakov, 2008, MySQL Enterprise Server 5.1, 2010, Cecchet, Chand, Einikety, Marguerite, & Zwaenepoel, 2010, Learn Computer, 2010, My Solutions, 2009, Sheldon & Moes, 2005, Misfit Greek, 2010.)

Some of these disadvantages reflect some limitations found in many open source software components. Proprietary LAMP alternatives provide better and easier-to-use administration tools, scalability options, fault tolerance, technical support, and development tools. From an IS curriculum point-of-view, the open source versions of LAMP are more than adequate. Many practitioners also use open-source alternatives for many limited scale, internal projects.

**Approaches of Using Lamp in the IS Curriculum**

LAMP may be used demonstrate dynamic web sites to a variety of audiences. Harris's PHP and MySQL book (2004) uses games like poker and dice to present basic programming structures, e.g., sequence, selection and iteration, and a simple database. Lecky-Thompson (2008) adds slightly more depth for beginner programmers to develop a simple content management.

LAMP also provides an excellent platform to provide a capstone course. LAMP text books provide many projects like: Online Address Books, Discussion Forums, Online Storefront and Shopping Carts (Meloni, 2008). PHP may also be used to present more advanced web applications, e.g., Ajax (Ballard & Moncur, 2009), application security (Shifflet, 2005), and web services (PHP.net, 2010). Finally, Lecky-Thompson (2005) uses PHP to cover object-oriented project management, analysis, design, application development, testing, and deployment.

## 3. CASE HISTORY OF LAMP-BASED COURSE IN A IS CURRICULUM

### The Need for a Dynamic Database-Driven Web Course

In 2007, the Computer Information Systems Department conducted a review its web development curriculum. It was discovered that all existing courses related to web development were based on the Windows platform. Courses offered included: Web Page Development (XHTML, HTML, CSS and JavaScript), VB.NET and ASP.NET, and Windows Server Administration. The only course based on an open source alternative was Linux System Administration. Further analysis of the curriculum and course content indicated that there were several deficiencies in the coverage of many components of a dynamic, database-driven platform. Some deficiencies cited included: web server and application server administration, database server administration, and inadequate coverage of enterprise and dynamic web applications.

Many IS curriculums are faced with the challenges of balancing currency with the content of existing courses with a new required or elective course. While the demand of industry may indicate a need for an Open Source Dynamic Database-Driven course, whether this proposed course be a developed as new course or should an existing course content be revised? For example, some faculty members questioned the emphasis on traditional application interfaces and algorithms, e.g., command line and data structures, at the expense of popular enterprise (multi-tiered) dynamic web applications. The debate continues.

In the fall of 2007, the CIS department decided to introduce a new elective course titled "Open Source eCommerce Development (LAMP)." The original objectives of this course were to: a) increase student awareness of open source technologies, b) present dynamic web, database-driven application development from a multi-tiered and administrative perspective, c) minimize course prerequisites, and d) be capable of delivery in a 15-week online instructional format.

This course's outcomes and topic coverage were designed to mirror those of existing courses, Linux System Administration, Database Management System, Introduction to Web Development, and Advanced Web Development (See the Appendix Table 1 for a comparison.)

Blackboard was used to provide online content and testing. A wide variety of detailed, instructor-developed tutorials were presented. Students were required to complete a semester application program and administration project. Experience using (X) HTML tables and forms was recommended. Course PHP application assignments did not require object-oriented or intermediate-level programming experience. Local and remote LAMP/WAMP alternatives were provided. Supplementary on-ground help sessions were provided.

Except for PHP, other course content areas were designed to be presented at an introductory-level. Database table layouts were provided to students. Each student was required to code the necessary MySQL code to implement the table layouts design and then insert test data.

Emphasis was placed on PHP as being the dynamic application interface between the web server, dynamic HTML content and the database. Several PHP code templates were provided to students. No GUI PHP editors or code generators, e.g., Eclipse or Zend Studio, were used. MySQL GUI administrative tools, e.g., PHPMYAdmin, were not used to create the database schema or enter test data.

### Local LAMP/WAMP

Early in the semester students were required to install WAMP or LAMP on their personal computer or server. All students had chosen a Windows-based solution, e.g., WAMP, for their personal computers. Advantages of local LAMP/WAMP installation included: a) experience in installing and debugging LAMP or WAMP installation, b) students had access to all PHP, MySQL and Apache configuration files (httpd.conf, my.cfg and php.ini), and c) students could use Windows-based editors and other utilities for which they may be more comfortable using. Disadvantages of local LAMP/WAMP installation included: a) the Linux Operating System was not in use, b) remote server access and administration may not be emphasized, c) limitations for instructor verification, and d) limitations for student collaboration.

### Course Public LAMP Web Site

Considering the advantages and disadvantages of local installation, a remote student-shared LAMP server was provided. Students were encouraged to use PuTTY and WinSCP open source utilities for SSH terminal access and file transferring. No Telnet or FTP was provided.

Students were not required to install or configure any LAMP resource on the student-shared server, e.g., Linux permissions, httpd.conf, my.cfg and php.ini. Each student was provided a Linux user account and home directory. Each student was provided an individual Apache name-based virtual web server and a MySQL database with appropriate administrative permissions.

Using an Apache name-based virtual web server each student was assigned a separate document root directory. Each student web developer was assigned the appropriate Linux file permissions by the instructor (root). Appropriate Linux file permissions to permit web content to be viewed by the public or other students were also assigned. No extra Apache authentication, authorization or access control restrictions were used in the initial setup. PHP script or SQL code/logic is not displayed or accessible in the internet browser window. As compared to static (X) HTML web pages, the intrinsic nature of dynamic, database-driven web development improves student collaboration while protecting the academic integrity of the source code.

Students could test or view their own or other student' web sites by entering an individual domain name into their internet browser address bar. An advantage of using Apache name-based virtual servers is that only one public IP address is required. The university's IT Services department entered each name-based subdomain name into the university's DNS server.

**Results of Course Offerings**

Two different sections of a 15-week online-format of Open Source eCommerce Web Development (LAMP) were offered and completed in Fall/2007 (n=15) and Fall/2008 (n=10). On-ground instructor-led, voluntary student-help sessions were scheduled on a weekly basis. Student retention and performance for both sections were disappointing. A detailed review of student tests, assignments, instructional materials, text, and student background was conducted. It was determined that the only significant factor for successful student retention and performance was their voluntary attendance at the weekly on-ground student-help sessions. It was decided that several changes were necessary.

A third section of Open Source eCommerce Web Development (LAMP) was offered and completed in Fall/2009 (n=11). The instructional delivery method was changed to a hybrid approach using a nine-week format. An on-ground class meeting was divided into two parts: an instructor demonstration/lecture and a student-help session. The course content, Blackboard support materials, tests, and assignments remained substantially un-changed. There was a change in the required textbook. At the instructional-level, only the delivery method and the textbook were significantly changed. At the technological infrastructure level, there was a change from the Apache name-based web server approach to a VMware-virtualized server. However, these changes in the technological infrastructure were transparent to the individual student.

Student retention and average assignment performance of students for the Fall/2009 section improved by 37% and 61% respectively. The small sample sizes for each course section limited statistical analysis for level of significance.

In addition, a section of Linux System Administration was also redeveloped in a 9-week hybrid format, and scheduled subsequent to the new course. Putting both of the courses together in the same term seemed to increase student interest and enrollment.

**Virtualization of the LAMP Infrastructure**

The technological infrastructure that supported the student's remote access to LAMP changed with the third section offered in Fall/2009. The student Apache Virtual Server configuration was replaced with an individual student, VMWare-virtualized, LAMP server. This permitted several advantages: a) each student was provided root access to their individual Linux server and could experiment and alter LAMP configuration files, e.g., httpd.conf, my.cfg and php.ini, b) the student VMware virtual server could be used for other current or future CIS department courses, e.g., Linux System Administration, c) remote access and web server browsing can be accessed by either IP address or DNS domain name, and d) the conceptual introduction of server virtualization into the course content. Since private IP addresses were mapped to public IP addresses, the IT department was required to properly configure the university routers, switches and firewalls

The change in the technological infrastructure to a VMware virtualization provided significant improvements and increased flexibility in course administration, e.g., virtual server clones, student isolation, and security. It is also important to note that improvements in retention and performance associated with the third section offering occurred in a nine-week course length rather than a fifteen-week course. While not an objective of this paper, the differences between online, on-ground, and hybrid instructional formats in relationship to program language curriculum needs to be investigated in context of a LAMP platform.

## 4. LESSONS LEARNED

Every curriculum change is accompanied by both challenges and opportunities. The primary challenge of integrating LAMP in this study seems to have nothing to do with content, but with the instructional delivery method chosen. It was originally decided that, "what other course would be better to offered in online instructional delivery method than a LAMP web application development course?" The results of this case study indicates that there was significant improvement in student performance and retention when the course was changed from an online format to a hybrid format, accompanied by instructor lectures, demonstrations, and lab time.

LAMP includes a significant programming language component, PHP. While PHP may be easy-to-learn, it may face the same instructional challenges as other programming languages. Student background data was not analyzed in this study and may be an intervening factor.

In a previously cited case study concerning the use an Open Source Java-based web development platform, Chung & McClane (2002) cited the amount of extra work required by instructors. While some text books in LAMP do exist, there was considerable amount of extra work required by the instructor to develop instructional materials, student documentation, and evaluation instruments for this LAMP course. LAMP is not a mainstream curricular topic like WISA, and hence, instructional support materials are limited.

While no empirical analysis was conducted, it was observed that student satisfaction seemed to be high when students completed their projects. It was concluded that students appreciated their success because they could better relate their in-class experiences to real-world dynamic, database-driven web sites.

The most significant opportunity and success of this case study was the technological implementation of LAMP using a VMWare Virtual server. While the low cost of Open Source software is well-known, scheduling, installing, and maintaining lab resources is a significant challenge. A $10,000 initial investment in a VMWare server originally permitted up to forty virtual student LAMP servers that could be accessed remotely by students and faculty.

The cooperation and coordination between the Robert Morris University's Computer Information Systems and Information Technology departments to set up the VMWare server was excellent. Creating and maintaining student virtual machines was the responsibility of the faculty member. While there was additional work required by the instructor to support the virtual infrastructure, it was significantly less than previous experiences of maintaining a physical lab environment. Furthermore, the benefits of applying virtualization to other IS courses which also required physical lab support not discussed, substantially exceeded the virtualization benefits of this LAMP case study.

## 5. SUMMARY AND CONCLUSION

Web development and programming have been included in the IS curriculum for many years. It may be desirable to view the IS web curriculum from an integrated platform perspective, rather than separate isolated individual courses. WISA (a Microsoft Windows-based platform) and LAMP (an open source-based platform) are two of many dynamic, database-driven web platforms used by industry. The ease-of-use of Windows-based dynamic web platforms may be a significant reason why many IS curricula embrace the Windows solution.

This paper reviewed the case history of adding a project-based LAMP course to an IS curriculum that is already Windows-centric. With a minimum of course prerequisites, students were introduced to an open source alternative to teach dynamic, database-driven web developments using Linux, Apache, MySQL and PHP. Preliminary data indicates that this type of LAMP course may not a good candidate for online delivery.

The focus of this paper was not to determine which dynamic web development platform was the best or should LAMP replace WISA. Rather, the conclusion of this paper indicates LAMP may complement any web development platform in use for a given IS curriculum, add to open source awareness, and provide IS students with a project experience with a minimum of course prerequisites.

The focus of this paper was to increase awareness of LAMP technologies within the IS curriculum. Further study is needed to determine the importance for LAMP technologies within industry and the IS curriculum. It is also recommended that additional study be conducted to determine the importance of the concept of "virtualization" as a content item in the IS Model Curriculum, as well as, its role of virtualization in supporting the IS curriculum.

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# Appendix

**Course Content in Relationship to Other Courses in the Curriculum (Table 1)**

| Open Source eCommerce Web Development (LAMP) Course Content | Related Courses and Sample Course Content |
|---|---|
| Putty and WinSCP<br>Introductory Linux commands and fundamental administration concepts, e.g., cat, ls, pwd, cd , mkdir, chmod, etc. | Linux System Administration – Introductory and intermediate-level Linux commands and administrative concepts, e.g., Linux file systems, processes, system initialization, shell programming, etc. |
| Fundamental relational database concepts, My SQL data definition (CREATE TABLE and INDEX) and data manipulation (INSERT, UPDATE, DELETE and SELECT) commands, and security concepts | Database Management Systems -<br>Data design and modeling, normalization, integrity concepts, introductory and intermediate-level Oracle SQL data definition and data manipulation commands, user administration and security, and introduction to PL/SQL |
| Review of (X)HTML tables and forms, CSS, and introductory JavaScript | Introduction to Web Development and eCommerce Technologies |
| Apache Administration Concepts and Security, httpd.conf, Apache user authentication, permissions and access control.<br>MySQL with Apache user authentication | Linux System Administration – Introductory Apache administration concepts. |

*Teaching Case*

# BI GIS Competition Brings DSS to AITP NCC

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**ABSTRACT**

A national student competition problem in business intelligence (BI) is considered to foster an understanding of this competition and of the underlying case study problem used. The focus here is two-fold. First, is to illustrate this competition, and second, is to provide a case problem that can be considered for use in various information systems courses. This case problem utilizes a commercially available, hosted software application that includes a rich econometric data set. The data are accessed using spatial queries and produce more than four dozen views of the data through predefined reports. Once the queries occur, the data can be analyzed further with other BI tools that include Microsoft Excel. The case problem requires this analysis of external business data to furnish information for business decision making. This NCC competition and its case problem approach have been successful for the past four years. Clearly, the experience of this competition can be applied to case-based, experiential learning in information system courses that include a BI component. This usage of the competition problem has been found to work well in several of these courses and should be considered by others for similar courses.

**Keywords:** Business intelligence, geographical information systems, case problems, decision support

## 1. INTRODUCTION

What is AITP NCC BI GIS? While active AITP faculty and members readily recognize these acronyms, they need to be defined for others. The Association of Information Technology Professionals (AITP) is a leading worldwide society of information technology business professionals and the community of knowledge for the current and next generation of information systems leaders. The purpose of the organization is to serve members by delivering relevant technology and leadership education, research and information on current business and technology issues, and forums for networking and collaboration. One of AITP's premier annual events is the National Collegiate Conference (NCC). The NCC has been held for each of the past 15 years. This conference continues to attract as many as 800 participants, primarily students from various colleges and universities in North America. These students participate in a variety of competitions, attend a number of presentations on current and emerging technology, interact with businesses through a job fair, and meet students from other colleges. This is an outstanding experience to broaden their perception of information technology careers and opportunities.

The Business Intelligence (BI) Geographical Information Systems (GIS) competition is one of more than a dozen competitions held at the NCC. This competition has been included in the NCC for the past four conferences. Other competitions include PC Troubleshooting, Systems Analysis and Design, Database Design, and Programming Languages. BI GIS is the only competition with an emphasis on business analytics, which is concerned with the use of information to support business decision making. Recently, the primary software used for the BI competition is Business Analyst Online (BAO) from Environmental Systems Research Institute (ESRI). This is a web-based, hosted application that features both a very rich set of GIS data and an interface that facilitates spatial queries of that data. BAO is a GIS tool, because it is designed for these spatial or geographical queries. Business data are displayed on a map to show spatial relationships from BAO's robust econometric database. Results from BAO GIS queries have the option to be delivered in the Microsoft Excel workbook file format, which straightaway supports additional analysis. Clearly, Excel is widely recognized as the leading software tool for end user BI analysis (Evelson, Moore, & Barnet, 2007; Palocasy, Markham, & Markham, 2010), which underscores it use with BAO. The analytics of the BI GIS competition blend commercially available, real-world external business–related information of BAO from ESRI and the Excel spreadsheet tool from Microsoft. Each is recognized as a leader in the advantage it delivers for BI analysis. The business analytics process is completed in Excel using the spatial query data from BAO. (See Figure 1, in Appendix)

The purpose here is twofold. First is to increase knowledge of an available BI tool which affords a substantial set of commercially available external business-oriented data for decision making. Second is to provide an example case problem for potential course usage. The desired outcome here is to impart an understanding of how the case problem from this competition might be utilized in information system courses, especially those with a current or planned BI module, and to increase awareness of this competition to encourage future participation by emerging information technology professionals, while they are still students.

## 2. BACKGROUND

The concept of BI has been around since it was first coined by Hans Luhn (1958). He defined it as: "the ability to apprehend the interrelationships of presented facts in such a way as to guide action towards a desired goal." According to Power (2007), it was in 1989 that Howard Dresner proposed BI as an umbrella term to describe "concepts and methods to improve business decision making by using fact-based support systems." However, it was not until the late 1990s that this usage became widespread. So, the tools for BI deployment have finally arrived to effectively and efficiently create Luhn's earlier vision. Today, SAP AG has a BI product, as do SAS, IBM, and others. BI is the present-day label for that half-century old idea, which is now supported by an array of advances in information technology (Anonymous, 2010). BI is the most recent characterization for many of the concepts of decision support systems (DSS), which have been around since the 1970's. DSS has gone through a number of "hot new names" to sell the latest iteration of software tools. This seems to be more of a software vendor marketing movement of the evolution of software tools than truly break-through, totally new technology. On the other hand, this evolution of tools, in concert with the development of the Internet, now makes these tools more cost effective and widely available. It is that availability which renders the BI GIS competition at the NCC the reality it is today.

Individually, software vendors vary their specific definitions of BI that match their particular tool and its unique capabilities. As a result, while there are similar views of what BI is, in general, there are also these individual differences. Without question, many software tools are available in the BI software tool space, where each has its unique features that make it the "best" tool for different analysis. For purposes of the NCC BI competition, a variety of tools were considered that would not only support DSS and BI queries, but also provided a rich dataset of information easily comprehended by student participants. BAO by ESRI includes a number of features that make it an exceptional tool to use with the NCC Competition. BAO's ample dataset houses a source of high-quality external data, which is of interest to a wide variety of different businesses. The econometric datasets in BAO supply this information, while operating with a user-friendly interface. Further, BAO is a hosted, web-based BI environment. This means that it is easily accessible by a large number of users without the need to create a separate hosting platform for both potential and actual contestants, as well as making it available for information system course usage. Further, ERSI agreed to provide BAO for this contest at no cost to students or the Conference itself. For these reasons, the NCC Competition presented here explores an example of a case problem, and by extension, an example hands-on BI analysis that should be considered for inclusion in information system courses.

## 3. BI AND DSS

The work of Gorry and Scott Morton (1989) is a classic reprint of their original work written in 1971. They indicate the usefulness of a framework is that it … "allows an organization to gain perspective on the field of information systems and can be a powerful means of providing focus and improving the effectiveness of the systems effort." Their framework postulates a number of parameters (Table 1, in Appendix) that are DSS characteristics. Additional corroboration for this framework is provided by Adam, Fahy, and Murphy (1998), who, after considerable evaluation of multiple perspectives, concluded that the Gorry and Scott Morton framework endures as it was originally advanced in 1971. The framework continues to provide substantial direction in the study and application of BI. "Largely External" is an information characteristic for Strategic Planning. That is, the information is obtained from sources other than the typical data housed in a business' own repository and used for its customary business activities. Demographic data is one example of this. So, where do businesses obtain this Largely External information? That is, how does DSS concept meet analytical reality? BAO is one alternative with its econometric datasets providing relevant business-oriented data for decision making, which is a key focus for the Strategic Planning category in Table 1. BAO serves as a stalwart means of obtaining high quality external information to support decision making in strategic planning. For this reason, BAO is an excellent candidate software tool for the NCC BI GIS competition. And, BAO changes the competition's emphasis to business problem solving rather than the mere collection, maintenance, and access of external data. Thus, the nucleus becomes one of selecting appropriate data for the problem at hand. A business maintains its competitive advantage not through its own storage and maintenance of this econometric data, but rather through the data selection and analysis performed. This is the analytical focal point of the BI GIS competition, and by extension, to a case problem for information system courses.

## 4. BAO SPATIAL QUERY

Maps are utilized recurrently to display spatial relationships of business-oriented data. Consequently, BAO uses maps in analyzing business data. A spatial query is a special type of database query supported by geodatabases. A geodatabase (also known as a spatial database) is a database designed to store, query, and manipulate geographic information and spatial data. Spatial queries differ from SQL queries in several important ways. Two of the most important are they permit the handling of geometry data types such as points, lines and polygons; and these queries take into account the spatial relationship between these geometries.

Within a spatial database, the econometric data is treated as any other data type. Vector data can be stored as point, line or polygon data types, and may have an associated spatial reference system. A geodatabase record exploits a geometry data type to represent the location of an object in the physical world and other standard database data types to store the object's associated attributes. Spatial databases are optimized to store and query data related to objects in space, including points and polygons. While typical databases can understand various numeric and character types of data, additional functionality needs to be included for databases to operate on spatial data types. These are typically called geometry or feature types.

BAO delivers spatial queries in three popular, easy to use arrangements – rings, drive times, and donuts; however, other more specialized areas can also be deployed. The three popular configurations are the ones that encompass the core of the competition problem. Each of these query types is considered next.

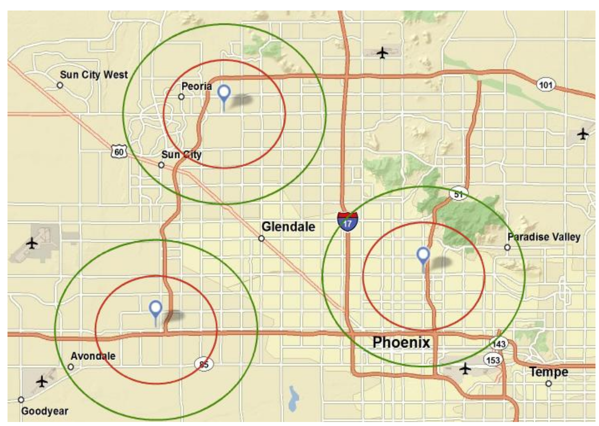


Figure 2: Ring spatial query

**Rings** – most widely used for market-area analysis, are circles generated on a map around a specified point. It is possible to choose up to three rings and indicate the radius, in miles, of the rings around the point. Report data are summarized for the area bounded by each ring.

That is, each of the outer rings includes the data from the rings inside that outer ring. Queries are cumulative for the entire area from the selected location point to the outer ring. (See Figure 2)


Figure 3: Drive time spatial query

**Drive Times** - represents how long it takes a customer to drive from a specified central location. These areas represent the distance traveled from the identified point on the map in a given amount of time. For example, a store's ten minute drive-time area defines the area in which drivers can reach the point in ten minutes or less. Travel time evaluation uses posted speed limits for the street segments. Here, each outer area comprises the data from the area inside of it. That is, it is cumulative or an overlap of the internal areas. This is the same approach as that for rings. (See Figure 3)

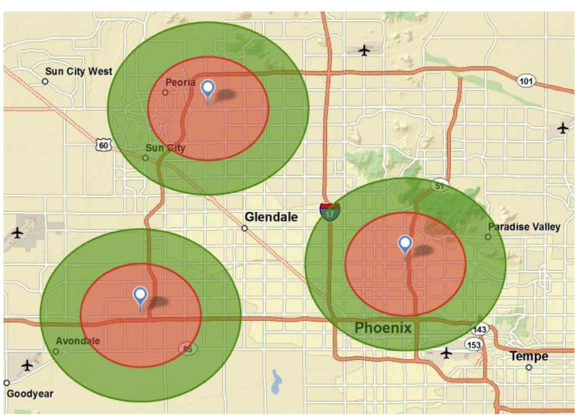


Figure 4: Donut spatial query

**Donuts** – study areas in a donut shape have no overlap and provide the traditional ring study area but without duplication of overlapping areas. That is, the query data for each area is mutually exclusive. Donuts are useful for recognizing the incremental market changes as you move away from a center location. For example, specifying donut values of 1, 3, and 5 miles will result in reports being generated for data from 0-1, 1-3, and 3-5 mile bands from the center. (See Figure 4)

## 5. BAO DATA

Why is BAO data appropriate for this NCC competition and hands-on case problems? BAO delivers data that is readily grasped by many people without in-depth knowledge of a particular business or industry. That is, it is reasonably industry non-specific. BAO data is commercially available, which signifies its value to many different businesses in a variety of industry sectors. BAO contains extensive demographic data, especially census data, as well as other econometric data portraying various industry sectors. Using their technologically advanced methodologies, ESRI presents updated census data projections every year. They offer a projected estimate for the current year and for five years in the future.

So, why conduct BI GIS through BAO? Yes, this is a limitation of the approach presented here. It is acknowledged there are other approaches to data marts for data warehouses that support other, different strategies to BI analytics. However, BI is a concept with many diverse facets. Clearly, BI GIS presents one of those views. A vision that uses a widely and readily available tool with an expansive data set, which contains data easily grasped by students with a variety of backgrounds with minimal effort.

### Market Profile

The Market Profile report (Figure 5, in Appendix) emphasizes population data. This includes data from the last census, a current year estimate, and a five year projected estimate. These estimates are provided by ESRI and use their advanced, proprietary methods of estimation. Population data is arranged by age group and by race or ethnicity. Household data includes the number of households, median income, and income by category. Other data includes per capital income, median age, employment by industry, employment by occupation, and spending by category.

### Retail Goods and Services Expenditures

The Retail Goods and Services report (Figure 6, in Appendix) contains current year estimates, five year projected estimates, a comparison to a national average index, and more detail of spending by category than the Market Profile report. In Figure 6, 2009 Consumer Spending shows the amount spent on a variety of goods and services by households that reside in the market area of the spatial query. Expenditures are shown by broad budget categories that are not mutually exclusive, so consumer spending does not equal business revenue. The Spending Potential Index represents the amount spent in the query area relative to a national average index of 100. This provides a quick analytic comparison of relative consumer expenditures.

**Retail Market Place Profile**

The Retail Market Place Profile report (Figure 7, in Appendix) displays data by industry groups. The data are provided for the Retail Demand, the Retail Supply, the Supply/Demand Gap, and the Supply/Leakage Factor. The factor is a percent measure of the retail gap divided by the sum of the demand (retail potential) and the supply (retail sales), where the retail gap is the difference between the demand and supply. These differences are exploited to produce a chart of the Supply/Leakage Factor (Figure 8, in Appendix) and compare graphically the various industry groups.

In Figure 7, Supply (retail sales) estimates sales to consumers by establishments. Sales to businesses are excluded. Demand (retail potential) assesses the expected amount spent by consumers at retail establishments. Supply and demand estimates are in current dollars. The Leakage/Surplus Factor presents a snapshot of retail opportunity. This is a measure of the relationship between supply and demand that ranges from +100 (total leakage) to -100 (total surplus). A positive value represents 'leakage' of retail opportunity outside the trade area. A negative value represents a surplus of retail sales, a market where customers are drawn in from outside the trade area. The Retail Gap represents the difference between Retail Potential and Retail Sales. ESRI uses the North American Industry Classification System (NAICS) to classify businesses by their primary type of economic pursuit. Retail establishments are classified into 27 industry groups in the Retail Trade sector, as well as four industry groups within the Food Services & Drinking Establishments subsector,

## 6. NCC COMPETITION PROBLEM

Clearly, the BI GIS competition problem is but one example of and approach to BI analytics. It is not presented here as the only method or as the absolute "best" method. Rather, it is one example of an approach that has proven itself through the NCC competition over several years. This history is an indicator of the success of this organization of the BI competition for a diverse group of contestants. The success underscores a reason for also considering the competition problem as a case problem for information system courses with a BI component.

The NCC competition problem involves site selection decision making. Contestants are given a case narrative which describes the details of the decision for which they are preparing a recommended course of action. (The 2010 BI GIS competition problem statement is available at http://my.mis.cmich.edu/BI/Problem.doc.) Site selection is for a retail business, which is a common business problem requiring decision making. The case problem statement provides a list of potential sites together with component costs of acquiring land and constructing a building. Contestants are guided in the selection of some data for the evaluation. This encompasses the industry sector, the expected service area of the business, and the expected share of the wallet for the business. Their task is to perform a financial analysis which includes a payback period and a revenue-to-assets ratio. Then, they provide a ranked list of the locations, which supports selecting the "best" sites, which may be within an indicated budget amount. That is, they must present the results for making a decision based on their analysis.

Contestants need to determine which BAO reports, from all the available reports, contain appropriate econometric data for their spatial queries. These data are then analyzed using a set of primary key factors and relationships presented in the NCC problem statement. The purpose is to furnish adequate direction for a common solution analysis and presentation, which can be judged readily. However, contestants must understand both the BAO data and the subsequent evaluation relationships in order to perform the case problem analysis. This stresses the necessity to do more than just retrieve the data for decision making. Clearly, the data require further analysis to provide the essential context for decision making. This is a typical situation for business decision making, which utilizes the 'Largely External' information requirements as postulated by Gorry and Scott-Morton (1989).

**Key Factors and Relationships**

Key factors and relationships establish the necessary guidance to direct contestants towards a relatively common solution for the NCC competition problem. This is where the BAO BI GIS bumps into Excel for BI analysis. Here, the BI confluence is a balancing situation. Adequate direction is set forth to achieve a reasonably common analysis for judging the competition, while challenging contestants in their use of BAO to acquire data and then conduct an appropriate analysis of that data using the ubiquitous BI tool Excel. Several of these factors and relationship are considered here to provide an overview of this direction.

- Primary and secondary service areas are set forth in miles and drive times with the data in these areas to be considered as non-overlapping data.
- A share of the wallet indicates a decrease in participation in the secondary area.
- The ring (or donut) and drive time service areas must support one another which is achieved by averaging the results for the different geographical areas. This requires contestants to do multiple queries in order to combine the influences on the results.
- The number of households and median disposable income are determined from the most recent estimates available within BAO.
- The NAICS classification of the business is specified.
- A table provides a mechanism for converting median disposable income into an expected amount spent for a location.
- A general description is outlined for each of the Location Summary Matrix items (Figure 9, in Appendix), which presents the averaged or summarized results that combine the two different query influences.

These factors and relationships indicate clearly that contestants must understand the BAO data to both perform the necessary spatial queries and carry out the subsequent analysis which leads to decision making. And, understanding the data is always a key factor in the analysis and solution of business problems, in general.

**Problem Solution**

The summarized calculations for each Location (Pad or Site) for the project scoring parameters are shown in Figure 9. These are the results from which the Location Scoring Index values are calculated for each parameter (Figure 10, in Appendix). The parameter indices are summed to yield the final, overall score for the location (site) in the Score column (column N). The Score values are used subsequently to rank the desirability of each location (Figure 11). Then, Figure 12 (See Appendix) graphically compares the location index scores. For comparability among solutions submitted for the competition, design sketches of Figures 9 and 11 are provided to contestants, but contain no data. This greatly assists in judging the submitted competition solutions and would be most useful in grading the solution for a case problem analysis submitted by students.

| | Rank Sort by Score | |
|---|---|---|
| Rank | Location | Score |
| 1 | 8 | 0.42 |
| 2 | 2 | 0.24 |
| 3 | 5 | 0.17 |
| 4 | 9 | 0.15 |
| 5 | 3 | 0.13 |
| 6 | 1 | 0.10 |
| 7 | 4 | 0.01 |
| 8 | 7 | -0.02 |
| 9 | 6 | -0.21 |

Figure 11: Location Index Scores sorted by sorted by rank

**NCC Competition Timeline**

Each year, the NCC competitions are announced by posting them to the competition web site at the end of October (Figure 13). Although many of the NCC competitions continue from year to year, some new ones are added, and old ones dropped or replaced. These changes depend on student participation each year and competition revisions recommended to the NCC organizing committee as advances in information technology occur and become mainstream technology. The October posting date provides student participants with time to determine in which competitions they will compete and to do their preparation for these competitions. For BAO, a guest access is available immediately when the competition is announced. This allows prospective contestants to explore and examine this software tool. Once a contestant has registered for the competition, they are supplied an enhanced access (Figure 13, Enhanced BAO Access), which provides them access to reports beyond those available with a guest access and includes all reports used with the competition. With the cutoffs for NCC registration, the enhanced access usually occurs during the first week of March. This is done to limit the full access to the BAO report suite to only registered contestants of the BI GIS competition, and not to all 800 attendees of the NCC. The limitation is done at the request of ESRI and is because of the commercial value of the data available through the BAO tool. The contestants use the enhanced BAO access setup at this time during the actual competition. The NCC competition then occurs at the end of March. Since the second year of this competition, prospective contestants have been provided access to prior year competition problems. Contestants can begin their preparation of the contest any time after the contest announcement. This permits them to better prepare for the competition and affords continuity of the access, which makes access available to them immediately at the beginning of the contest. That is, they have registered already for access, so that process occurs before the competition and gives additional time for the competition analysis. Then, the enhanced BAO access continues for contestants until a week after the completion of the competition at the NCC and enables them to go back and review their solutions.

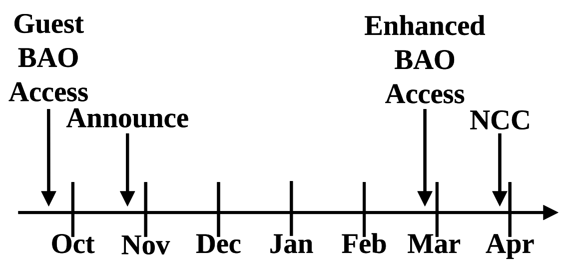

Figure 13: NCC Competition Timeline

**Other NCC Problem Usage**

NCC competition case problems from prior years have been used in both undergraduate and graduate courses in decision support systems and business intelligence at the author's university. The competition problem is used as an applied BI case problem for student analysis. Based on comments from students, the BI GIS case is well received. They appreciate the ability to use commercially available, leading-edge applications in BI to solve business problems. Also, course instructors, other than the author, have used the NCC competition problem as a case application problem in these courses. These instructors have reported they have found the cases works well as a major case application in their course. Based on these experiences, other educators should consider using the NCC competition problems as case applications in their courses, which contain a BI component that can be demonstrated with the BAO GIS software application. Also, this can serve as preparation for the next year's NCC BI GIS competition.

## 7. CONCLUSION

The BI GIS competition at the AITP NCC offers a means for students to demonstrate their comprehension of BI using the ESRI BAO software, which is a BI tool with a rich set of econometric data. BAO is a commercially available, hosted software application that provides over 50 views of its data through a variety of reports. The BAO data are accessed through spatial queries that provide geo-coded data for business analytics. This permits NCC contestants and other students to work with this software that is readily available in the business environment to deliver external data, which can be used to support decision making.

The NCC BI GIS competition problem provides a case application that can be considered for use in various business courses which contain a BI component. It furnishes a user-friendly environment for obtaining external business-oriented data that are frequently included in decision support system applications. Problems created for the NCC competition have been found to work well in providing a hands-on, experientially-based case in decision support systems courses that include a BI component. A limitation of BAO is that it is a data mart which is oriented around spatial queries with geo-coded data, and, hence, is not a general data mart. On the other hand, an advantage of BAO is the rich econometric data that is does provide and has application in a wide-variety of businesses. Overall, BAO combined with Excel have provided an excellent environment for the NCC BI GIS competition and does represent a strong, readily available candidate for experiential, case-based learning in decision support systems and related courses.

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## 9. APPENDIX


Figure 1: BAO processing and analysis

Table 1: Information Requirements by Decision Category

| Characteristics of Information | Operational Control | Managerial Control | Strategic Planning |
|---|---|---|---|
| Source | Largely internal | → | Largely External |
| Scope | Well defined, narrow | → | Very wide |
| Level of Aggregation | Detailed | → | Aggregate |
| Time Horizon | Historical | → | Future |
| Currency | Highly current | → | Quite old |
| Required Accuracy | High | → | Low |
| Frequency of Use | Very frequent | → | Infrequent |

DSS

SOURCE: Gorry and Scott-Morton (1989)

**Market Profile**

| | | | |
|---|---|---|---|
| Site Type: Rings Pad 1 | | 10050 W Mcdowell Rd | 10050 W Mcdowell Rd |
| Latitude: 33.46487 | | Avondale, AZ 85392-4803 | Avondale, AZ 85392-4803 |
| Longitude: -112.27583 | | Radius: 3 Miles | Radius: 5 Miles |
| 2000 Total Population | | 53,867 | 164,124 |
| 2000 Group Quarters | | 3 | 222 |
| 2009 Total Population | | 97,836 | 272,571 |
| 2014 Total Population | | 117,978 | 323,118 |
| 2009 - 2014 Annual Rate | | 3.82% | 3.46% |
| 2000 Households | | 15,963 | 47,942 |
| 2000 Average Household Size | | 3.37 | 3.42 |
| 2009 Households | | 28,781 | 79,449 |
| 2009 Average Household Size | | 3.40 | 3.43 |
| 2014 Households | | 34,631 | 94,124 |
| 2014 Average Household Size | | 3.41 | 3.43 |
| 2009 - 2014 Annual Rate | | 3.77% | 3.45% |
| 2000 Families | | 13,203 | 39,150 |
| 2000 Average Family Size | | 3.64 | 3.71 |
| 2009 Families | | 22,555 | 62,394 |
| 2009 Average Family Size | | 3.76 | 3.78 |
| 2014 Families | | 26,612 | 72,685 |
| 2014 Average Family Size | | 3.79 | 3.80 |
| 2009 - 2014 Annual Rate | | 3.36% | 3.10% |
| **2000 Housing Units** | | 16,781 | 50,381 |
| Owner Occupied Housing Units | | 78.4% | 70.0% |
| Renter Occupied Housing Units | | 17.2% | 25.1% |
| Vacant Housing Units | | 4.4% | 5.0% |

Figure 5: Market profile population data

**Retail Goods and Services Expenditures**

| | | | | |
|---|---|---|---|---|
| **Pad 1** | | | **Latitude:** | **33.46487** |
| **10050 W Mcdowell Rd** | | | **Longitude:** | **-112.27583** |
| **Avondale, AZ 85392-4803** | **Site Type:** | **Drive Time** | **Drive Time:** | **5 Minutes** |

| **Top Tapestry Segments:** | | **Demographic Summary** | **2009** | **2014** |
|---|---|---|---|---|
| Up and Coming Families | 80.2% | Population | 29,647 | 35,684 |
| Industrious Urban Fringe | 9.3% | Households | 9,139 | 11,065 |
| Milk and Cookies | 5.5% | Families | 7,101 | 8,409 |
| Sophisticated Squires | 4.2% | Median Age | 31.2 | 31.6 |
| Inner City Tenants | 0.7% | Median Household Income | $71,485 | $74,756 |

| | **Spending Potential Index** | **Average Amount Spent** | **Total** |
|---|---|---|---|
| **Apparel and Services** | 80 | $2,012.09 | $18,388,455 |
| Men's | 76 | $366.06 | $3,345,440 |
| Women's | 70 | $603.79 | $5,518,036 |
| Children's | 91 | $376.13 | $3,437,465 |
| Footwear | 55 | $236.96 | $2,165,567 |
| Watches & Jewelry | 120 | $255.54 | $2,335,392 |
| Apparel Products and Services (1) | 171 | $173.60 | $1,586,554 |
| **Computer** | | | |
| Computers and Hardware for Home Use | 119 | $238.41 | $2,178,855 |
| Software and Accessories for Home Use | 121 | $34.57 | $315,933 |
| **Entertainment & Recreation** | 115 | $3,737.73 | $34,159,070 |
| **Fees and Admissions** | 121 | $753.82 | $6,889,117 |
| Membership Fees for Clubs (2) | 117 | $200.51 | $1,832,469 |
| Fees for Participant Sports, excl. Trips | 124 | $136.88 | $1,250,948 |

Figure 6: Retail goods and services expenditures by industry group

**Retail MarketPlace Profile**

| | | | | |
|---|---|---|---|---|
| **Pad 1** | | | **Latitude:** | **33.46487** |
| **10050 W Mcdowell Rd** | | | **Longitude:** | **-112.27583** |
| **Avondale, AZ 85392-4803** | **Site Type:** | **Drive Time** | **Drive Time:** | **5 Minutes** |

| **Summary Demographics** | |
|---|---|
| 2009 Population | 29,647 |
| 2009 Households | 9,139 |
| 2009 Median Disposable Income | $56,320 |
| 2009 Per Capita Income | $24,992 |

| **Industry Summary** | **Demand (Retail Potential)** | **Supply (Retail Sales)** | **Retail Gap (Demand - Supply)** | **Surplus / Leakage Factor** | **Number of Businesses** |
|---|---|---|---|---|---|
| Total Retail Trade and Food & Drink (NAICS 44-45, 722) | $282,308,397 | $418,119,963 | -$135,811,566 | -19.4 | 144 |
| Total Retail Trade (NAICS 44-45) | $239,195,337 | $372,929,373 | -$133,734,036 | -21.8 | 93 |
| Total Food & Drink (NAICS 722) | $43,113,060 | $45,190,590 | -$2,077,530 | -2.4 | 51 |

| **Industry Group** | **Demand (Retail Potential)** | **Supply (Retail Sales)** | **Retail Gap** | **Surplus / Leakage Factor** | **Number of Businesses** |
|---|---|---|---|---|---|
| Motor Vehicle & Parts Dealers (NAICS 441) | $63,162,983 | $228,328,794 | -$165,165,811 | -56.7 | 12 |
| Automobile Dealers (NAICS 4411) | $54,088,947 | $221,464,059 | -$167,375,112 | -60.7 | 7 |
| Other Motor Vehicle Dealers (NAICS 4412) | $4,372,853 | $4,952,232 | -$579,379 | -6.2 | 2 |
| Auto Parts, Accessories, and Tire Stores (NAICS 4413) | $4,701,183 | $1,912,503 | $2,788,680 | 42.2 | 3 |
| | | | | | |
| Furniture & Home Furnishings Stores (NAICS 442) | $9,887,253 | $7,704,303 | $2,182,950 | 12.4 | 10 |
| Furniture Stores (NAICS 4421) | $6,439,379 | $6,664,341 | -$224,962 | -1.7 | 7 |
| Home Furnishings Stores (NAICS 4422) | $3,447,874 | $1,039,962 | $2,407,912 | 53.7 | 3 |

Figure 7: Retail market place profile industry data

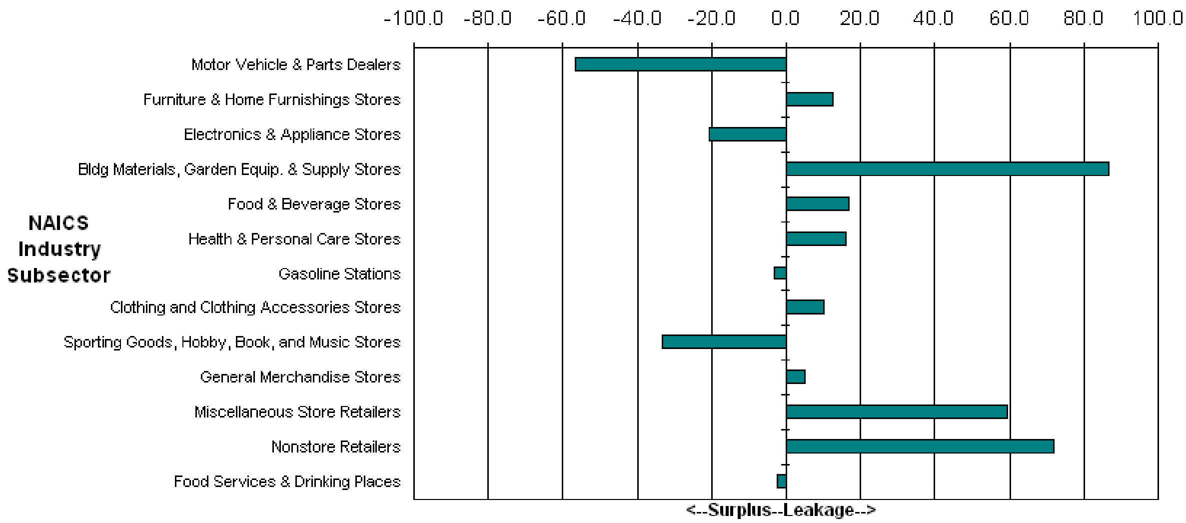


Figure 8: Leakage/surplus factor by industry subsector

| Location | cex Index Avg | NAICS Leakage | EBT | Payback | HH |
|---|---|---|---|---|---|
| 1 | 83 | 6.6% | 176,020 | 44.1 | 49,128 |
| 2 | 85 | -16.3% | 366,371 | 24.9 | 94,311 |
| 3 | 98 | -28.0% | 279,164 | 26.0 | 69,700 |
| 4 | 62 | -63.4% | 310,773 | 20.1 | 92,320 |
| 5 | 73 | 6.9% | 228,948 | 35.5 | 63,810 |
| 6 | 136 | -85.0% | 191,797 | 41.2 | 34,280 |
| 7 | 108 | -66.5% | 226,640 | 14.2 | 47,094 |
| 8 | 69 | 20.8% | 382,709 | 20.6 | 108,540 |
| 9 | 68 | -19.8% | 365,682 | 17.3 | 44,116 |
| Total | 781 | 244.7% | 2,528,106 | 244 | 603,300 |

Figure 9: Summarized decision parameters

| Location | cex Index Avg | NAICS Leakage | EBT | Payback | HH | | Score |
|---|---|---|---|---|---|---|---|
| 1 | 0.11 | 0.03 | 0.07 | -0.18 | 0.08 | | 0.10 |
| 2 | 0.11 | -0.07 | 0.14 | -0.10 | 0.16 | | 0.24 |
| 3 | 0.13 | -0.11 | 0.11 | -0.11 | 0.12 | | 0.13 |
| 4 | 0.08 | -0.26 | 0.12 | -0.08 | 0.15 | | 0.01 |
| 5 | 0.09 | 0.03 | 0.09 | -0.15 | 0.11 | | 0.17 |
| 6 | 0.17 | -0.35 | 0.08 | -0.17 | 0.06 | | -0.21 |
| 7 | 0.14 | -0.27 | 0.09 | -0.06 | 0.08 | | -0.02 |
| 8 | 0.09 | 0.08 | 0.15 | -0.08 | 0.18 | | 0.42 |
| 9 | 0.09 | -0.08 | 0.14 | -0.07 | 0.07 | | 0.15 |
| Total | | | | | | | |

Figure 10: Location Scoring Index summary

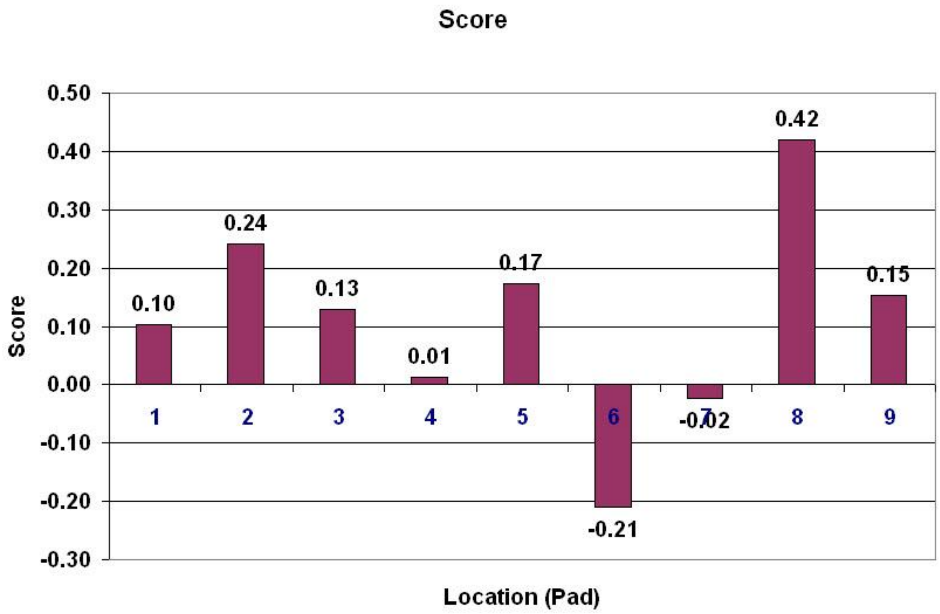


Figure 12: Comparison of location index scores