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INFORMATION SYSTEMS EDUCATION JOURNAL

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Creating and Using a Computer Networking and Systems Administration Laboratory Built Under Relaxed Financial Constraints

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Abstract

The Computer Science Department at Slippery Rock University created a laboratory for its Computer Networks and System Administration and Security courses under relaxed financial constraints. This paper describes the department's experience designing and using this laboratory, including lessons learned and descriptions of some student projects performed in the lab.

Keywords: computer laboratory, hardware, laboratory, network, security, systems administration

1. INTRODUCTION

Designing a laboratory for teaching about networking and security is difficult. Many papers have been written about experiences designing and using computer network labs, often in cases of significant or even severe constraints on the cost of the space and equipment for the lab:

Riabov (2006) describes the use of a network simulator called *Virtual Opnet* for a small college without a networking lab. Crowley (2006) describes a network project performed with "live" CD's and open-source tools, obviating the need for installed software in a dedicated lab. Kretzer and Frank (2005) and Yuan and Zhong (2008) suggest using labs of surplused computers and open-source software for security lab activities. Other authors suggest a laboratory using equipment emulation, which they state will save more than ninety percent of the lab equipment cost (Li, Pickard, Li, Mohammed, Yang, and Augustus, 2008). Krap (2004) suggests the use of *User Mode Linux*, which enables the creation of multiple Linux instances on virtual machines on a Linux host. He points out that networks of virtual machines can be readily re-configured, but that many virtualization technologies suffer from poor performance.

It may be instructive to compare these experiences with that of a lab created without such constraints, and using real hardware. This paper addresses one computer science department's experience with a laboratory for computer networking and system administration developed at a time when there were few significant financial constraints in designing and equipping the lab.

In 2002, Slippery Rock University began the process of designing a new science and technology building. At that time, the Computer Science Department's network and security lab consisted of a collection of surplused computers, in an inappropriate facility with very poor reliability. Because of this problem, and the generally poor facilities of the department at that time, we embarked on a serious effort to

specify appropriate computer laboratories for future needs. We were not given significant budget constraints, so we asked for all the facilities that we believed we could reasonably use, anticipating that some of our requests would subsequently be denied. Surprisingly, virtually all of the department's requests for the new building were granted. The most elaborate of the requested facilities was the Network and Systems Administration Laboratory.

2. NETWORK LAB REQUIREMENTS

The lab was designed for use by Computer Science, Information Systems, and Information Technology majors in the *Computer Networks* course and by students in the *Systems Administration and Security* course, who are almost exclusively Information Technology majors. While the lab facility requirements of the two courses are not identical, the requirements had significant overlap and no conflict, especially since these two courses run in different semesters. Students in both courses need experience setting up servers, workstations, routers, switches, firewalls, etc. Computer Science majors in the Networks course need experience writing network software. Both courses, but especially the SysAdmin and Security course, should provide their students with experience using cracking and intrusion-detection software.

It was decided that the optimal lab for department needs should serve thirty students. Each student should have a desktop workstation and exclusive administrative access to several servers. Each student workstation should have access to its associated servers at a hardware level, so that servers and workstations can be administered before, during, and after operating system installation.

As emphasized by Kretzer and Frank (2005), the lab network must be disconnected from the campus network so that lab experiments will not interfere with ordinary campus communication. Other researchers agree: Hill et al. warn that a non-isolated security lab could be used by external crackers to attack systems in the campus network (Hill, Carver, Humphries, and Pooch, 2001). Bullers et al. report a campus-wide *Code Red* worm infestation originating in a lab that was not isolated (Bullers, Burd, and Seazzu, 2006).

Since it will be necessary at times to obtain software from the Internet, a firewalled-connection to the department's Unix server would allow a two-step software download: first to the Unix server, then to the student's workstation or server. The firewall would prevent student access to the rest of the campus network from the lab, since lab operations might interfere with ordinary campus network operation.

The lab was to have a flexible network configuration in order to make it easy to modify the topology of the lab network. The purpose of this was to allow students to partition the network into subnets to permit installation of routers and firewalls, and to permit students to study the kinds of problems that arise on LAN's of multiple subnets.

Refining the Lab's Requirements

As is often the case, some of the specifications turned out to be impractical. For example, it was thought that "blades" would make the best servers for the lab, because of their compact size and popularity in commercial server farms.

Blades consist of a set of book-sized computers installed in a case approximately 6 rack-units ("6U") high, with about 12 servers per case. However, all of the blades in the case share a single optical drive. This meant that when one student was using the optical drive, such as for operating system installation, other students needing the optical drive for their blades would be forced to wait, perhaps for many hours. 1U servers, by contrast, are complete PC's in a one-rack-unit-high package, including optical drive, and USB, video, and network ports, so there are no delays from hardware sharing.

With 1U servers, thirty servers with network switches and switches for keyboard, video, and mouse, fit in a single rack. The entire lab could be outfitted with three such racks. Had blades been appropriate for a student network lab, two sparsely-filled racks would have sufficed.

The university's networking staff ruled that Internet access through the Unix server was unsafe for the campus network. This led to the use of "sneakernet": students would download software in a nearby lab and carry it into the Network/Admin Lab on flash drive. This was unsatisfactory, but we had to live with it for some time.

Illustration 1: View of the Network/Systems Administration Laboratory. Two of the three racks of servers can be seen in the background.

Eventually, during a campus-wide network upgrade, it became possible to route all outgoing packets from the lab directly to the university's Internet gateway. This worked out better than the original proposal, allowing software downloads in a one-step process, yet protecting the campus network from lab activity. It would be better still if faculty could turn this connection on and off, preventing Internet access except when needed for a particular lab project.

It was thought that the desktop computers could be configured with several operating systems in a multi-boot configuration, enabling additional courses to make use of the lab. The idea was that the first disk partition would contain a copy of Windows to be used for courses such as *Productivity Software*, so students could learn computer procedures that are disallowed in other labs, such as installation of software. However, since SysAdmin and Networking students need to install operating systems on the remaining partitions, the original partition turned out to be too vulnerable to be relied upon.

The lab has occasionally been used for activities other than its main networking-and-sysadmin purpose. In particular, operating systems students have used the lab for kernel-level programming projects, but this has depended on the enrollment in Networks or Sysadmin being small enough to leave several workstations and associated servers unassigned. It may yet be possible to use the desktops for additional purposes, with the rise of "live" Linux distributions. This is the only lab where live distributions would be usable, since computers in other labs will not boot from removable media. Because of the cost of maintaining the lab, efforts are continuing to find ways to increase lab utilization without compromising its original purpose.

3. THE ACTUAL LAB

The Computer Network and Administration Laboratory at Slippery Rock University contains thirty desktop computers and ninety servers. The lab is networked with gigabit Ethernet, and connected to the rest of the Internet through a firewall that prevents computers in the lab from communicating with other computers on campus. Each functional unit (composed of keyboard, monitor, and mouse) is connected to a local/remote KVM (keyboard-video-mouse) switch, enabling a student to switch between the local desktop computer and a remote switch, which, in turn, lets the user select which of three servers to address (Illustration 2).

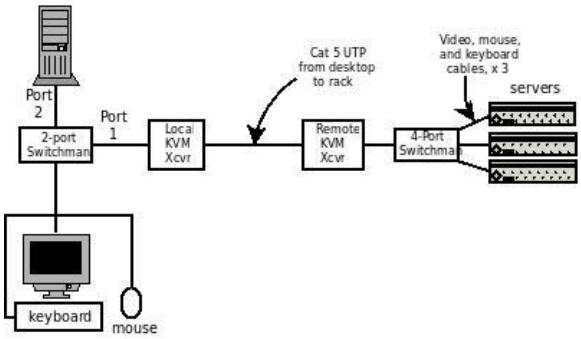

Illustration 2: KVM Switch Wiring. The local switch selects the local workstation (port 2) or a KVM transceiver (Port 1). Special key-strokes enable the user to select any one of three servers attached to the remote 4 port KVM.

There is a considerable collection of cables running between the racks and the workstations, or part-way along that path, with the potential for a considerable tangle of cabling. Rather than just tie them together with nylon tie-wraps, which would make re-cabling difficult, a cable trough was installed to hold the cables (Illustration 3). The trough runs along the back of each row of desks. Because the troughs are made of heavy-gauge steel wiring with large gaps between the wire, cables can enter or exit the trough at almost any point, in any direction.

At the end of each row, network cables follow a riser to the ceiling, where they enter a horizontal ladder-like device (Illustration 4). This ladder runs perpendicular to the rows of desks, carrying network cables from row to row. Such cable-carrying ladders are common in newer

construction; here, the difference is that the ladder is mounted below the ceiling so that cabling can be accessed without disturbing the ceiling tiles. The arrangement of troughs and the ladder permits re-routing and addition of network cables quite easily.

Illustration 3: View of a row of workstations, showing the wire trough for laying network cabling.

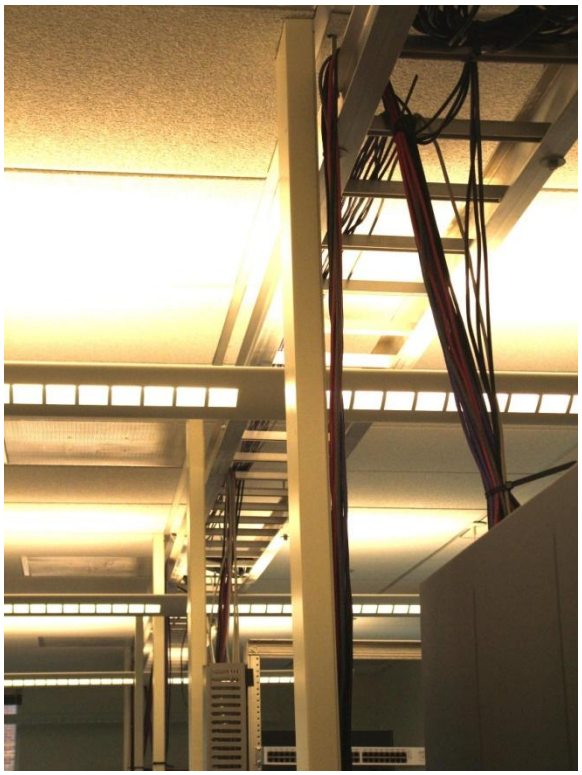

Illustration 4: The "ladder" carrying network cabling between rows of workstations. Note the bundle of cables rising obliquely from the server rack (right foreground) to the ladder, and vertical bundles of cables running from the ladder down to the trough below (not shown).

At the end of each row, network cables follow a riser to the ceiling, where they enter a horizontal ladder-like device (Illustration 4). This ladder runs perpendicular to the rows of desks, carrying network cables from row to row. Such cable-carrying ladders are common in newer construction; here, the difference is that the ladder is mounted below the ceiling so that cabling can be accessed without disturbing the ceiling tiles. The arrangement of troughs and the ladder permits re-routing and addition of network cables quite easily.

Despite all this, however, the goal of having an easily-reconfigurable network was not reached, because cabling to the network switches inside the racks was so congested physically that rewiring of the servers' network cables is very difficult. Each server has two network interfaces, but only one from each server has ever been used because of the difficulty of access. Experience has shown that it would have been better to put the network switches into a separate rack with patch panels, allowing rerouting without needing to work inside a congested rack. Fortunately, the flexible layout of the lab will allow this change to be implemented without difficulty.

4. LAB PROJECTS

In the Systems Administration and Security course, 50% of class time is spent in lab, with an additional three hours per week of required lab time. In the Computer Networks course, all lab time is outside scheduled class time.

As with much of the previously cited research, most of the lab projects utilize open-source software, which is free to download, sophisticated, and abundant. However, some of it, notably *OpenLDAP*, can be quite difficult to configure.

Systems Administration Course Projects

Because so many of today's students have never partitioned a disk or installed an operating system, partitioning and OS installation are among the first projects assigned. An alternate approach could be to have a technician perform the partitioning and installation, but, in the opinion of the authors, operating-system installation is an essential experience for future systems administrators.

A typical set of project for Systems Administration and Security in approximately sequential order is:

- Determine hardware configuration (CPU type, types and quantities of ports, monitor resolution, available I/O devices, installed RAM, etc.)
- Partition the hard drive and install Windows and Linux side-by-side (dual-boot) on the desktop computer.
- Install Windows server on two servers and Linux on the other server.
- Install all available updates.
- Install any necessary software and configure the software so that each server can be managed, using a graphical user interface, from either desktop OS, without use of the KVM switches.
- Use Bastille Linux to harden the student's Linux server.
- Set up the Linux server to be a DHCP server.
- Set up the Windows server to be a Windows domain controller.
- Set up the Linux systems to use the Windows domain controller for authentication.
- Set up the Linux server to be a Domain Name Server.
- Set up the Windows server as a file server.
- Write a bash script to extract student information from a mainframe report to create Unix accounts on the server for each student in the class.

It was hoped that students could go well beyond these basic projects. Additional projects considered included such things as testing password complexity, monitoring network communication, attempting intrusions, or configuring firewalls. However, our experience is that very few students finish all of the basic projects listed above.

Computer Networks Course Projects

Designing appropriate projects for a course that contains Computer Science, Information Systems, and Information Technology majors requires considerable thought. Computer Science majors ought to be writing network programs. Information Systems majors are generally not strong enough as programmers to write sophisticated software, and instead need experience with selecting and installing networking software. Information Technology majors have had considerable script-programming experience but have limited experience with general-purpose languages such as C++ or Java. All majors should get some experience working with existing network software.

Illustration 5: Rack of 30 1-U servers. Note the boxes of KVM switches above each cluster of six servers. The bottom three servers in the middle cluster have their escutcheons removed to allow access the optical drives and USB ports.

A possible solution to this problem is to assign alternate projects by major. There was hesitancy to do this, because some students might perceive that other students could get the same grade by doing "easier" work. Eventually, a solution was found to this quandary.

For part of their lab grade, students are given the choice of writing a server or installing and configuring several servers. To date, all CS majors have voluntarily chosen the software project, because writing one program is easier for them than doing several server projects. IS majors have all chosen the server-installation projects, and IT majors have split between the two.

IS and IT students cannot completely avoid programming, however. All students are expected to write a time server and a time client to coordinate the clocks on their desktop and servers. This software is relatively easy to write, and students of all majors have completed this project successfully.

To make the software easier to write and debug, the projects are to be written in Python. Experience has shown that network projects written in Python are much easier to implement than equivalent projects in C++ or Java, even though students in the course normally have no prior Python experience. This also gives students expertise in an additional language, thus helping to fulfill an ABET accreditation requirement.

The result is that everyone does (an) appropriate project(s) without being assigned their projects by major, and the difficulty of the programming projects are not so great as to preclude additional lab projects.

Typical lab projects for Computer Networks include:

- Install client and server operating systems (just as is done in Systems Administration and Security).
- Write a time server and time clients to coordinate the clocks on your servers and client.
- Set up an Apache Web server with a MySQL server feeding it data.
- Write a simple multi-threaded Web server, serving only GET and HEAD methods.
- Set up an anonymous FTP server.
- Set up a Jabber instant messaging system with both Linux and Windows clients.
- Set up Linux Samba as a file server for Windows clients.
- Use Linux OpenLDAP to authenticate Windows and Linux clients. (Tough!)

Other Projects

There are many other projects that have been considered for students who use this lab. The world of open source software includes many programs around which valuable projects can be built. While our students have not attempted many of these projects, some readers of this paper may find such projects worth considering:

- Set up printing for both Linux and Windows, using the same printer.
- Back up the servers using Bacula.
- Set up an iptables firewall on the Linux server. This can be simplified through the use of arlo-iptables-firewall, ferm, fiaif, guarddog, gnome-lokkit, kmyfirewall, knetfilter, or lokkit.
- Set up chillispot to operate a wireless hotspot.
- Use the following programs to attack machines and detect security problems:
  - Nessus
  - Snort
  - Crack and/or John
  - aide
  - rkhunter
  - tiger
  - tinyhoneypot, honeyd, or labrea
  - ettercap
  - fragroute, fragrouter
  - idswakeup and hping2
  - portsentry

5. HARDWARE PROBLEMS IMPEDE PROGRESS

As mentioned previously, students in both courses complete a surprisingly small number of lab projects. One reason for this is that sophisticated projects generally depend on more-basic ones, and cannot be attempted until the basic ones are completed.

Another problem has been a succession of hardware failures. Particularly surprising was the rate of critical hardware problems in this lab; this rate seems greater than in our professionally configured labs, which are used by large numbers of students daily. The technician expressed little surprise at this, stating that booting problems are common in computers that are not up and running continuously.

Hardware problems have increased over the four years that the lab has been in use, so that reliability during the fourth year was becoming a serious problem. Normally, the university replaces computers every three years, but upgrading this lab was delayed a year to put all servers in this lab into the same year of the replacement cycle. Campuses with cycles longer

than three years can expect diminished usefulness in such a lab beyond the third year.

Typical hardware problems included:

- Computer won't boot from the optical drive, preventing OS installation.
- Operating system installation fails for no apparent reason.
- Computer dead.
- KVM switch will not switch between desktop computer and server rack.
- KVM switch will not switch among servers.
- Hard drive not recognized.
- Network interface not detected during OS installation, and no network driver installed.
- Linux server software cannot negotiate video parameters with monitor over the KVM switching system.

Any one of these problems will delay a student considerably. While the technician has provided excellent support, the delays do compound and students fall behind. While it should be possible to install operating systems on three servers and a desktop dual boot Windows/Linux configuration within a few hours, or a few days for inexperienced students, our experience has been that often a significant minority of students does not have all of their computers configured one-third of the way into the semester, and much of the delay is caused by hardware problems.

That being said, it is also important to note that many students do rise to the occasion when problems develop. All students need to learn that hardware problems will occur, even in production facilities, and it is the job of the network or system administrator to find solutions in the face of such difficulties.

6. CONCLUSIONS

Adequate funding and proper planning are necessary but not always sufficient to guarantee a successful computer networking laboratory. Sufficient technical support is needed to keep facilities working, else students' experiences will fall short of expectations. Facilities must be upgraded regularly to assure lab success. However, good students will often rise to the occasion when hardware fails them, and they will find ways around their problems; this develops the kind of confidence that computing graduates ought to have. Overall, this lab has worked very well for the department and students, and it serves as a showpiece for visitors.

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Teach or No Teach: Is Large System Education Resurging?

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ABSTRACT

Legacy or not, mainframe education is being taught at many U. S. universities. Some computer science programs have always had some large system content but there does appear to be resurgence of mainframe related content in business programs such as Management Information Systems (MIS) and Computer Information Systems (CIS). Many companies such as financial institutions have relied on large systems for years. Other companies are turning to mainframe computing as a reliable and economic efficient way of meeting their everyday needs. Additionally, in an ever increasing environmentally conscious environment, "green" solution of computing are sought. In this paper, we sought the opinions of academic members of IBM's Academic Initiative program and the Enterprise Computing Community (ECC) to ascertain the decisions to address large systems content and the future of mainframe education.

Keywords: mainframe education, curriculum

1. INTRODUCTION

Technology and Information Systems curriculum decisions are always challenging as new technologies emerge and older technologies change or no longer provide competitive advantage. In training IS/IT professionals, universities must continually assess what they teach. Graduates must enter the workforce with tangible skills that will add value to an organization from day one. Organizations are less likely to hire based on potential with the intent to provide on the job training for the specific skills needed. Therefore, educators must be vigilant of market demand for IS/IT workers.

Large systems, particularly the term "mainframes" are often thought of as legacy but mainframe computing continues to be the solution for many organizations (Greenemeier, 2002; Lohr, 2008). "Mainframe computers are more reliable, cost effective and in the long run easier to maintain (Murphy, Sharma, Seay, & McClelland, 2010)." Additionally, they offer better solutions in an environmentally conscience community.

Many large systems specialists are reaching or have reached retirement age. If mainframe computing solutions continue to grow and the trained specialists leave the workforce, it stands

to reason that a need for newly trained specialists will increase. So is this claim real and are academics slow to react or is the current interest in mainframe computing short-lived? In this paper, we seek the opinions of the members of IBM's Academic Initiative in an attempt to determine the future of mainframe education.

2. MAINFRAME AND ACADEMICS

Many current mainframe workers were trained in the 60's and 70's and are reaching or have reached retirement. These retirements and increasing interest by companies in large systems solutions will require newly trained mainframe specialists. Many of the current IS/IT graduates do not possess the necessary skills and training to secure even an entry level position in an organization that relies heavily on mainframe computing. The failure to educate students in mainframe technology is leading to a shortage of trained workers (Burt, 2008).

A review of model curriculums in IS, End User Computing and Computing (Brookshire, Hunt, Yin, & Crews, 2007; Computing Curricula 2005, 2005; IS 2009 Model Curricula, 2009) identify the need for courses in operating systems and hardware/software in general but the course descriptions do not recognize mainframe systems. Enterprise system courses are suggested but the descriptions do not specifically recognize that for large organizations these systems are often implemented on a mainframe computer.

The belief that the mainframe is a legacy system translates to little or no interest among current students to seek large systems training. Adding to that notion is the fact that mainframes are largely invisible and implemented behind the scenes as opposed to personal computers that everyone owns. Many people, including students, do not realize that they are using mainframe computing on a daily basis through the use of ATM's for banking transactions or utilities such as their cellular phone. Large systems are viable, powerful and an environmentally friendly computing solution for many industries.

Cloud computing is becoming more available not only on college campuses and universities but organizations such as Google, Apple, Amazon and AT&T are building large computer platforms. The mainframe is a reliable implementation strategy for much of the virtualization world (Murphy & McClelland, 2009).

3. ACADEMIC RESPONSE

IBM Academic Initiative Program

"IBM Academic Initiative is a global program that facilitates the collaboration between IBM and educators to teach students the information technology skills they need to be competitive and keep pace with changes in the workplace ("IBM Academic Initiative Program," 2010)."

Members have access to a variety of hardware and software without cost. Additionally, the program offers professional course content, training, tools and books.

Enterprise Computing Community (ECC)

The ECC was formed as a result of a "National Science Foundation grant received by Marist College and 8 academic partners and 9 industry partners in September 2008. The primary mission is to improve undergraduate education in large systems and graduate a new generation of talent that will provide industries with the ability to secure, sustain, and grow their operations. Filling the skills shortage will stabilize a vulnerable technology environment before the problem reaches crisis proportions ("Marist College," 2008)."

We surveyed 85 members of this community to ascertain their opinions on mainframe education. A copy of the survey is on Table 1 of the Appendix.

Survey Data collection

In order to ascertain the direction of mainframe education in traditional academic setting, we conducted an online survey of 85 members of the academic community from 81 distinct schools.

Of the 81 distinct schools and colleges that were contacted, 20 responses were received with a response rate of approximately 25%. This percentage is a representative sample that is sufficient to capture the key dynamics and highlight current trends in mainframe education. The survey respondents are coded using letters A through T to represent the 20 responding schools.

As is consistent with most exploratory qualitative studies most of the questions on the survey are open ended. The data was analyzed by coding the survey responses and identifying underlying themes and trends in current mainframe education by the authors.

Survey Results and Findings

Key findings of the survey are presented in Tables 2, 3 and 4 of the appendix. Table 2 highlights the current and future trends in teaching mainframe content. Table 3 provides insight into the proposed expansion of the current mainframe curriculum, perceived student interest in mainframe courses and industry demand for mainframe programs. Table 4 presents a summary of the quotes from the respondents on the future of mainframe education at their school.

Fifty five percent of the responding schools are currently teaching mainframe content and will continue to do so in the future too. This suggests that there is a market for their students in which mainframe skills are in demand. Such schools are also able to generate student interest as students perceive mainframe courses to be stepping stones to a future job.

Seven of the eleven schools in our sample that currently teach mainframe related courses plan to expand their current curriculum and add new content. The respondent from school K shares the underlying reason for their inclusion of Mainframe related content "We have plans to continue with our 2 COBOL classes. They are a major incentive for three Fortune 100 companies to target our graduates as well as include many students in their formal internship programs".

Two schools (C and E) currently offer mainframe related content but do not wish to do so in the future. The primary reason for the discontinuity is that their students are not hired by companies needing mainframe skills. Two schools (F and Q) do not currently offer mainframe related content but plan to do so in the future. However, they expressed concern in their ability to generate student interest.

Five schools that responded to our survey do not presently teach mainframe content and do not intend to do so in the future. Of these five schools, two schools (A and R) consider mainframe a niche market of which they do not consider themselves a part of. Three schools (D, L and S) perceive high demand and need for mainframe skills but cite lack of student interest as the reason for not having a mainframe related course offering.

The survey results indicate that 70% of our respondents feel that the current large systems training and skills imparted to undergraduates are insufficient compared to the demand for such skills in the industry. As one of the respondents mentioned, "There is a large demand for students that understand large systems and enterprise level technologies. We see many companies looking for students that can understand large complex problems. Having students only work on small computers and small problems does not adequately prepare the students for the issues that most organizations are facing. There will be an increase demand for students that can view problems from a large system perspective." Another respondent indicated the lack of student interest and a widening gap between supply and demand for such skills. "Its (sic) a dying art with little interest by students. Too bad because it is a needed skill." The quotes from the respondents are summarized in Table 4 in the Appendix.

Programs of Study

Regardless of whether mainframe education is resurging, a niche market or insignificant, some universities have felt the need to create and/or expand their programs.

The Information Systems Department in the School of Business at the University of Arkansas has an Enterprise System program. The success of this program is evident by the student enrollment from 5 to 50 students (Douglas & Davis, 2009). A significant element of the program's success is its focus on bridging the learning styles of baby boomers and Gen-Y students through the introduction of Rational Developer for System z and Linux Web Development into their courses.

The School of Computer Science and Mathematics at Marist College offer programs in Computer Science, Information Systems and Information Technology. The school is extensively involved in increasing undergraduate education in large systems.

For universities who want to gradually add large systems content joining the IBM Academic Initiative can be quite beneficial. Members can invite experts to teach classes, guest lecture and/or lead class discussions on large systems. Additionally, schools could introducing large systems topics into other courses such as Operating Systems and Hardware/Architecture (Corridori, 2009).

North Carolina Central University

North Carolina Central University (NCCU) is primarily a liberal arts school with approximately 8,300 students. The Computer Information

Systems (CIS) discipline in the school of business began investigating the introduction of mainframes to the students in 2005. An introduction to mainframe course was first offered in 2006 and every semester through 2009 as a Special Topics elective. The introduction of this course led to numerous internships and placements.

Based on an intensive curriculum review in 2008 and 2009 that included review of our market and opinions of our advisory board, large systems became a required CIS course and two other courses were added to the curriculum as electives.

Placements and Internships: The Business School at NCCU has approximately 100 CIS majors and graduates approximately 20 per year. Four graduates were placed in mainframe positions in 2007, 5 in 2008, 5 in 2009 and 7 in 2010. The average salary was $60K and many had an additional $5K sign on bonus. Additionally, 7 students in 2009 and 4 in 2010 received mainframe summer internships paying $26 per hour.

Who is hiring: For an IS program of our size, we have had a significant number of placements in mainframe positions. Many of our placements are in the banking industry, however recent graduates have also been placed in both the insurance sector and among independent software vendors (ISVs, or companies that develop software to support and/or run on mainframes). A major ISV has shared with us that they plan to hire 1,000 mainframe professionals over the next 10 years.**CONCLUSIONS**

A primary goal of an IS/IT program is to provide students with the opportunity to obtain jobs. Therefore, every school must be aware of the target market for their students. Research clearly indicates that the need for mainframe specialists is increasing. This fact is readily seen by many respondents. Even those schools which do not currently offer mainframe related courses at least recognize that organizations are seeking students with exposure to large systems.

None of the responding schools including those that have active mainframe related programs were able to provide information on the number of graduates who were placed in mainframe shops. A better tracking of placements is needed to ascertain who are getting jobs and where.

Some of the schools that do perceive demand from the industry but find low student interest for mainframe related courses may benefit by tracking mainframe related placements and by making a stronger case for mainframe skills to students. In many cases the students may be unfamiliar with the technology or may perceive it as being distant or legacy. However, an example of their continued relevance combined with information on potential job opportunities may significantly increase student interest.

In this paper, we investigate the academic response to the need for large systems specialists. Our survey targeted a section of the academic community that presumably had an interest in large systems as indicated by membership in the IBM Academic Initiative and/or the ECC. Regardless, at least in this survey, there is a trend to increase large system content in the curriculum.

In future research, we plan to expand our survey to a wider group of academics. At least some in the academic community see mainframe education as a very small niche market at best. Perhaps the issue is not the market of mainframe specialists but in the educators as noted by respondent D ("need to educate the educator"). The only way to truly answer this question is to track the job trend.

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Editor's Note:

This paper was selected for inclusion in the journal as an ISECON 2010 Meritorious Paper. The acceptance rate is typically 15% for this category of paper based on blind reviews from six or more peers including three or more former best papers authors who did not submit a paper in 2010.

Appendix

Table 1: Large Computer Systems Survey

Large Computer Systems

What undergraduate programs do you offer in your department/area? Check as many as apply.
Computer Information Systems Management Information Systems Computer Science Information Technology/Systems Other

If other, please describe.

How many mainframe related courses do you offer in your department/area? Enter number of courses (0, 1, 2, 3...).

List the names of all of your courses that you offer which have mainframe content.

If you currently do not offer courses with large system content, do you intend to in the future? Please explain.

How many students in all programs offered by your department/area graduated in 2009? If you do not know this information, please check "I don't know."
I don't know

Enter number (0, 1, 2, 3...) of 2009 graduates for all programs (approximation is ok)

How many of your total graduates for all programs in your department/area in 2009 were placed? If you do not know this information, please check "I don't know."
I don't know

Enter number (0, 1, 2, 3...) of 2009 graduates for all programs placed in a position (approximation is ok)

How many of your total 2009 graduate placements for all programs in your department/area received jobs related to large systems or in a mainframe shop? If you do not know this information, please check "I don't know."
I don't know

Enter the number (0, 1, 2, 3...) of 2009 graduate placements for all programs that are working in large system related jobs (approximation is ok).

How many students in all programs offered by your department/area graduated in 2010? If you do not know this information, please check "I don't know."
I don't know

Enter number (0, 1, 2, 3...) of 2010 graduates for all programs (approximation is ok)

How many of your total graduates for all programs in your department/area in 2010 were placed? If you do not know this information, please check "I don't know."
I don't know

Enter number (0, 1, 2, 3...) of 2010 graduates for all programs placed in a position (approximation is ok)

How many of your total 2010 graduate placements for all programs in your department/area received jobs related to large systems or in a mainframe shop? If you do not know this information, please check "I don't know."
I don't know

Enter the number (0, 1, 2, 3...) of 2010 graduate placements for all programs that are working in large system related jobs (approximation is ok).

How do you see the future for mainframe/enterprise systems/large systems content in undergraduate programs at your university? Please explain and provide as much detail as possible.

The name of your university will not be collected or identified.

Table 2: Current and Future Trends in teaching mainframe content

	Currently Teaching Mainframe content and will continue to teach in future	Currently Teaching Mainframe content but will stop teaching in future	Currently not teaching mainframe content but plan to teach in the future	Currently not teaching mainframe content and do not intend to do so in future
Schools	B,G,H,I,J,K,M,N,O,P,T	C,E	F,Q	A,D,L,R,S
Number	11	2	2	5
Percentage of respondents	55%	10%	10%	25%

Table 3: Expansion, Student Interest and Industry Demand for Mainframe Programs

	Currently teaching and will expand the current mainframe curriculum	Currently not teaching and perceive low student interest in mainframe content	Currently not teaching and perceive high industry demand for mainframe skills
Schools	G,I,J,N,O,P,T	F,L,Q	D,L,S
Number	7	4	3
Percentage of respondents	35%	20%	15%

Table 4: Summary of respondent quotes on the future of Mainframe program in their School

School	Program	# of current mainframe related courses	Quotes from respondents
A	Information Technology/Systems	0	Mainframe, enterprise systems, and large systems content are all different topics depending on your view. We teach students how to build clusters and grid computing structures which can be large systems and enterprise systems without the knowledge or inclusion of a mainframe. We do not at this point foresee anytime (sic) in the near future teaching our students details about mainframe structures or OS but we do teach our students about enterprise systems and large systems from a modeling perspective, support perspective, etc.
B	BS in Information	3	There is a large demand for students that understand large systems and enterprise level technologies. We see

	Management & Technology		many companies looking for students that can understand large complex problems. Having students only work on small computers and small problems does not adequately prepare the students for the issues that most organizations are facing. There will be an increase demand for students that can view problems from a large system perspective.
C	Information Technology/Systems	1	We will be eliminating them in favor of Windows administration
D	Computer Science	0	There is a need for such graduates; there is a need to educate the educators
E	Computer Science Computer Programming and Database	1	Not good. First we are a Community College, and second most of the jobs we are asked to fill are not mainframe jobs.
F	Management Information Systems	0	I doubt that large systems courses will be in demand. Plan to offer course in future but unsure
G	Computer Science, Information Technology/Systems	7	Growing Rapidly!
H	Information Technology/Systems	1	there doesnot (sic) seem to be much interest at this time
I	Computer Science	3	We plan to continue our approach of having this platform included in the core of the major plus the elective. Assembler is likely to change to no longer be required and may be folded into another course and be no longer mainframe based.
J	Information Technology/Systems, High performance, mainframe	6	Will increase, share content with HPC, cloud
K	Computer Information Systems	2	We have plans to continue with our 2 COBOL classes. They are a major incentive for 3 "Fortune 100" companies to target our graduates as well as include many students in their formal internship programs.
L	Computer Information Systems, Computer Science, Information Technology/Systems	0	its (sic) a dying art with little interest by students. too (sic) bad because it is a needed skill. no interest from students couldn't fill a class if we paid them
M	Management Information Systems	3	We will continue to develop students in mainframe technologies - we have many companies that specially come here just for our mainframe students.
N	Management Information	1	need to change the CIT 327 Structured Cobol course into a more general "enterprise systems" course

	Systems, Computer Science		
O	Computer Science	1	Where (sic) are currently infusing zOS technology into a set of eight (8) courses.
P	Computer Information Systems, Computer Science	1	This was our first year offering a complete mainframe course. In other years, we offered a seminar course. All students are required to take the course and I plan on adding another class soon.
Q	Management Information Systems, Computer Science, Information Technology/Systems	0	IBM is still offering training for our undergraduates in the area of mainframe. But due to the small number of students, it is difficult to attract students in this area. Moving to cloud computing, call it a new mainframe
R	Computer Information Systems, Computer Science	0	Mainframe is at best a niche market.
S	Computer Science	0	Needed. Those in the 50plus age range are about to retire and thus new employees need to have knowledge of large systems to maintain current applications/systems.
T	Information Management & Technology, Global Enterprise Technologies	6	The content will continue to get more detailed. We have just scratched the surface and plan to bring the content down a number of levels especially with operating systems. We also plan to integrate more content in other courses like including enterprise thinking into the systems analysis courses.

Assessing Blackboard: Improving Online Instructional Delivery

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Abstract

Universities and colleges have been offering online classes without assessing the tools used for online learning management to determine student perceptions. An understanding of the benefits and concerns as perceived by the student population is essential to implementing an online education environment that is conducive to a student's learning. This paper provides a quantitative assessment of Blackboard, an online learning management system (LMS), at a small rural Mid-Atlantic university. A survey was distributed to 119 undergraduate and graduate students to discover their perceptions of the benefits and drawbacks of the technology. This survey was based upon a study that was conducted at the University of Denver in 2006. The results of the survey were analyzed to understand the students' perceptions of this technology and to identify areas for improvement.

Keywords: University, Blackboard, Online, Learning

1. INTRODUCTION

Universities and colleges have strived to improve instructional techniques and methodologies to enhance the learning experience for the students. Distance learning enables universities to make learning accessible to larger student populations. Online programs and courses make learning accessible to students who are unable to physically attend classes on campus. Factors such as distance, cost, time constraints, job requirements, and family demands, can preclude students from attending traditional classes. Online courses enable students to balance the demands of their daily lives by setting their own schedule for learning.

Educational institutions all over the world offer classroom instruction via web-based learning management systems. As of March 2010, it was determined that one in every four students registers for online classes (Allen and Seaman, 2010). Given this growing demand for online classes, it is important for universities and colleges to implement online learning tools that are effective from the perspective of the students. For the purpose of this study we will assess students' perceptions of the benefits and drawbacks of Blackboard, an online learning management system (LMS).

2. LITERATURE REVIEW

Online learning is increasing at a rapid pace. Advances in technology and the Internet have changed the way people access and use information. A recent 2010 higher education study conducted by Allen and Seamon on the state of online learning in higher education in the United States revealed that over 4.6 million students were taking at least one online course during the 2008-2009 fall semesters. This reflected a 17 percent increase from the previous year. The 17 percent growth rate for online enrollments far exceeded the 1.2 percent growth of the overall higher education student population (Allen & Seaman, 2010). This trend shows that an increasing number of people are enrolling in distance learning programs to complete their degrees in order to compete in today's job market and to advance in their careers.

Dorado, et al. (2009) conducted an exploratory study of factors that influence a student's decisions to take online courses. The study examined four key elements: convenience, level of difficulty, effectiveness, and social interaction. Convenience and effectiveness were both perceived by students as a positive influence in their decision to take online courses. Level of difficulty and social interaction were perceived by students as negative influences in their decision to take online courses. The study revealed that convenience was the major factor that influenced a student to take online courses.

In her 2008 study of student perceptions of various components of the Blackboard e-learning system at a historically black, rural university, Buzzetto-More (2008) found an increased level of communications and interactions in online classrooms. Of the 121 students that completed the study, 63.5 percent indicated increased learner-to-instructor interactions, 61.9 percent agreed that there was a significant increase in the overall volume of communications in the online classroom, and 52 percent revealed that the e-learning website fostered community in the classroom. The students liked the functionality of their e-learning system: 78.1 percent of the respondents indicated that the hyperlinked calendar was particularly valuable, 79.9 percent considered lecture notes to be valuable, and 80.9 percent agreed that e-learning systems make the classroom handouts readily available and accessible. The respondents also found online learning to be effective and accessible: 68.2 percent specified that the online discussions helped them to understand and assimilate the course content and 79.8 percent preferred submitting assignments online.

A study conducted by Hannay and Newvine (2006) indicated that students prefer online education, because it allows them to balance their life demands while going to school. The researchers sought to determine the reasons for the students' interest in distance learning. Students could select more than one option as the basis for their decision to attend an online program. Twenty percent of the participants chose distance learning, because the courses necessary to complete their degrees were only offered at limited times in the brick and mortar campuses but were scheduled more often in the world of online education. Approximately 88 percent of students chose distance learning, because they had other commitments that precluded them from physically attending courses on campus. The study also indicated that 59 percent of students surveyed reported that their grades were higher in distance learning than traditional courses, and 70 percent of students indicated that they preferred online courses. A particular interesting finding of the study was that 90 percent of students read the textbooks associated with their online courses as compared to just 60 percent of students that read the textbooks in traditional classes.

According to Blackboard (Blackboard Inc, 2000) students have enhanced learning experience when using the online tools associated with its web-based learning management system. The web-based tools available in Blackboard to enhance communication and interaction between class members and faculty include discussion boards, email, and chat rooms. The online forums enable students to share their perspectives and experiences with their peers and their instructors. Blackboard enables instructors to adapt their assignments, discussion boards, and other teaching materials to the various learning styles of the students by including interactive graphics, audio, and video. Blackboard makes course materials available to students twenty-four hours a day, seven days a week, allowing students to access their education at their convenience. Students can balance the demands on their time and also maximize the classroom experience.

The University of Denver's Center for Teaching and Learning's Courseware Faculty Advisory Board (CFAB) completed a study on their utilization of Blackboard. The Board (The Center, 2006) distributed a survey via email to approximately 8,000 students who had at least one instructor that utilized Blackboard to assist with courses. A total of 1,821 students completed the survey. Approximately 51 percent of the students reported using Blackboard in 75 percent of their classes. The students reported that the weekly announcements and grade book were the most useful tools in Blackboard. Nearly 90 percent of students attested that Blackboard was an excellent web-based tool. Fewer than two percent of the students reported having had a bad experience with Blackboard.

The number one reason that students from the University of Denver study liked Blackboard was the access to the course materials at all times. They also perceived that there was a high level of communication with their instructors. Other benefits included the immediate access to their grades, improved class discussions, and the ability to view assignments. Approximately 82 percent of students preferred courses that utilize Blackboard or other web-based tools as compared to just 10 percent of students that did not (The Center, 2006).

The Board also focused on determining the perceived faults and drawbacks of courses that use Blackboard. The major drawbacks identified were the instructors' lack of knowledge of Blackboard, the inconsistent use of Blackboard, technology problems, access issues, and lack of exploitation of Blackboards' full functionality (The Center, 2006).

The study sought to determine the features that students would like to have Blackboard change, as well as, the tools or features they would like to see implemented. The most common enhancements that students desired included email alerts when content had been changed or added, an improved digital dropbox for students to submit their assignments, and an enhanced discussion board interface.

Lastly, the students were asked to identify the Blackboard features or tools that should be implemented in the classroom. These features included the email and notification system, access to the class roster, the course calendar and the chat tool (The Center, 2006). Some of the tools that the students wanted to see added to Blackboard already existed; this lack of knowledge indicated that additional training would be beneficial to the students.

3. METHODOLOGY

Online classes enable universities to reach students all over the world. The online environment offers unique advantages over traditional learning environments; it allows students to access the classes at their own convenience day or night. The purpose of this study is to assess students' perceptions of the benefits and drawbacks of Blackboard, an online learning management system.

This study explores the following research questions:

RQ1: What features of Blackboard are students using in their courses?

RQ2: What are the benefits and drawbacks of Blackboard?

RQ3: What modifications to Blackboard will be beneficial to the students' learning experience?

This study examined student perceptions of Blackboard, an online learning management tool, at a small rural Mid-Atlantic University during March 2010. This study utilized a quantitative methodology to assess the benefits and drawbacks of Blackboard. The population chosen for the student survey was comprised of undergraduate and graduate students.

Undergraduate and graduate students were surveyed in order to gather data from students 18 years of age or older. The survey was conducted using Survey Monkey, an online survey tool; it was made available to 9,017 students from March 18, 2010 through April 19, 2010. A total of 119 residential and non-residential students completed the survey.

The survey questions focused on obtaining information from students who had used Blackboard. The majority of the survey was developed from a partial replication of a 2006 (The Center, 2006) *Blackboard Student Survey Report* conducted at the University of Denver. The researchers developed additional questions to obtain insights that were not captured in the original study. The survey results were analyzed using SPSS, a software tool for statistical analysis. This study used Chi-square with a statistical significance at the .05 margin of error with a 95% confidence level to determine student's perceived benefits and drawbacks of Blackboard. Statistical frequencies were used to

determine the basis for the student's use of Blackboard as well as the benefits and drawbacks of using the online learning management tool. The study used a convenience sample, surveying students from the School of Arts and Humanities, Business, Science and Math, Engineering, Computer Science, Information Technology, and Psychology.

The survey instrument consisted of 15 closed-ended questions (some allowing the optional open-ended response "other") and 1 open-ended question. The first four questions focused on student demographics, which included, gender, age, education and degree program. Question five, a contingency question, asked students if they had taken any online distance learning classes. If the students answered yes, they continued to question six, which asked if they had used Blackboard in particular. If the students answered yes to using Blackboard, they were to continue with the survey. If the answer was no in either of these questions, they were instructed to stop answering the questions and exit the survey. In other words, students that had no prior experience with using Blackboard were precluded from filling out the survey. Questions 7-9 focused on the tools and features used, and questions 10-12 assessed students' satisfaction. Questions 13-15 addressed the benefits and drawbacks of using the online assessment tool. The final question was designed to elicit an open-ended response about the features that they would like to see used in added to Blackboard.

4. RESULTS

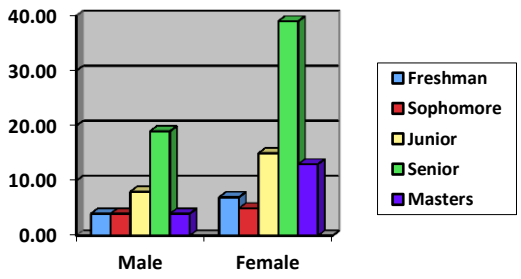

Figure 1: Education Level Categorized by Gender

The survey responses were analyzed to determine the basis for their choice of instructional format and the benefits or drawbacks of using Blackboard. The overall student demographic data indicated that 33.1% of the respondents were male and 66.9% of were female. The demographic information is further detailed in relation to gender in Figure 1 and Table 1.

Table 1: Demographic Breakdown of Survey Participants

Demographic Information	***Male***	***Female***
Age:		
18-25	*18.5%*	*35.3%*
26-35	*4.2%*	*10.1%*
36-45	*6.1%*	*9.8%*
46-55	*2.5%*	*10.9%*
56-65	*1.7%*	*0.8%*
Education Level:		
Freshman	*3.4%*	*5.9%*
Sophomore	*3.4%*	*4.2%*
Junior	*6.8%*	*12.7%*
Senior	*16.1%*	*33.1%*
Masters	*3.4%*	*11%*
Degree:		
Arts and Humanities	*2.6%*	*10.4%*
Business	*15.7%*	*21.7%*
Education	*0.9%*	*15.7%*
Science & Math	*3.5%*	*7.8%*
Engineering	*7.0%*	*0.0%*
Computer Science	*0.0%*	*0.9%*
Information Systems	*0.9%*	*0.0%*
Information Technology	*0.9%*	*0.9%*
Psychology	*0.9%*	*7.8%*
Undecided	*0.0%*	*2.6%*
Online Classes Before		
Yes	*27.1%*	*54.2%*
No	*6.8%*	*11.9%*

Figure 1 categorizes the percentage of males and females according to their education level. For every education level, the percentage of female respondents is larger than the corresponding percentage of male respondents. For both genders, the senior and junior standing students had the highest response rate. Table 1 depicts the percentage of students for each gender in relation to age bracket, education levels, degree programs, and their prior

experience with online classes. The largest percentage of respondents for both genders is in the 18-25 age brackets. The percentage of female respondents is consistently larger than the corresponding percentage of male respondents in all age brackets with the exception of the 56-65 age bracket where male respondents outnumbered female respondents by a factor of 2:1. The most popular program for both genders was Arts and Humanities. The next set of popular programs for female respondents was Education and Arts and Humanities. On the other hand, the next set of popular programs for male respondents was Engineering and Science and Math.

Basis for Classroom Format

Survey question five asked if the students had previously taken an online class. If they answered "yes," they proceeded to provide input about the instructional format. If they answered "no", they received a "Thank You for Participating" message and did not complete the remainder of the survey. Since this survey assesses a user's experience and perception of Blackboard, it only makes sense that students who answered "no" be eliminated from participating in the survey.

Table 2: Students' Reasons for Specific Instructional Format

Format Reasons	***Online***	***In The Class-room***	***Blended***	***Total***
Faculty	*5*	*18*	*22*	*45*
Format	*12*	*15*	*12*	*39*
Time Constraints	*36*	*8*	*26*	*68*
Learning Effectiveness	*5*	*29*	*30*	*64*
Pedagogy	*1*	*7*	*1*	*9*
Accessibility	*22*	*6*	*15*	*43*
Privacy	*5*	*0*	*2*	*7*
Learning Style	*20*	*32*	*28*	*80*
Community	*0*	*9*	*3*	*12*

Of the 119 respondents that started the survey 96 answered "yes," to taking online classes and 22 answered "no." One student did not answer this question and, based upon the missing responses for the remainder of the questions for this student, it can only be assumed that the student exited the survey at that point.

Question six prompted the students to choose their preferred instructional format: 31% of the students chose "Online," 27% chose "In the Classroom", and 37% chose "Blended." The respondents were then asked to identify the reasons for their choice of instructional format and were permitted to select more than one response. The most popular reasons included: Time Constraints for Online Classes, Learning Style for In the Classroom, and Learning Effectiveness for Blended. Table 2 identifies additional reasons for each of the instructional formats. Each value in the table represents the number of respondents who selected that particular reason.

Blackboard Tools/Features Used

Table 3: Percentage of Students Using Each Feature

Blackboard Feature	**Percentage of Students Using Feature**
Announcement	89.1%
Syllabus	89.9%
Post Content	25.2%
Discussion Board	90.7%
Email	47.9%
Digital Dropbox	67.2%
Quizzes and Surveys	81.5%
Group Tools	32.8%
Collaboration (Chat)	12.6%
Feedback during Grading	24.4%
Imbedded Audio/Video	16.0%
Blackboard Mobile	1.7%
Notification System	7.6%

In order to answer research question 1, the students were asked to identify the tools and features they used in Blackboard. The top five features included Announcements (89.1%), Syllabus (89.9%), Discussion Board (90.7%), Digital Dropbox (67.2%), and Quizzes / Surveys (81.5%). Slightly less than half of the

population identified Email as a feature that was used within Blackboard. Table 3 summarizes the percentage of students using specific features.

Benefits and Drawbacks

Research question #2 sought to determine the perceived benefits and drawbacks of Blackboard. The highest ranked benefits identified by the students included the ability to readily check grades, the 24x7 access to course materials, and the overall accessibility to the Blackboard system. The least ranked responses were collaborative group projects and team development activities to build community and enhance team cohesiveness. The responses to the perceived benefits of Blackboard are summarized in Table 4.

Table 4: Benefits of Blackboard

I like Blackboard because:	Total
Checking Grades	90.8%
Ease of access to course materials	83.2%
Accessibility	73.0%
Promote group discussion	31.9%
Quality of assessments	27.7%
Access to the instructor	24.4%
Solicit feedback from peers and the instructor	23.5%
Enhance team cohesiveness	10.1%
Collaborative group projects	8.4%

Table 5: Drawbacks of Blackboard

Drawbacks	Total
Inconsistent use of Blackboard by instructors	62.2%
Professors don't know how to use it effectively	48.7%
Not used to its potential	45.4%
Problems with technology/access issues	31.1%
Have to print everything yourself	19.3%

Just like the Blackboard Student Survey Report of 2006 (The Center, 2006), this survey allowed students to identify the potential drawbacks of using Blackboard. The two highest ranked drawbacks were a lack of standardization in Blackboard and the instructor's lack of knowledge of Blackboard. Other drawbacks identified were technology problems, access issues, and the need for students to print out the course documents for their reference. It is important to note this was a closed-ended question and many of these responses did not have additional comments from the student. These drawbacks are summarized in Table 5.

Awareness of Blackboard Features

Each respondent was asked to identify their awareness of Blackboard features such as email, notifications, audio/video/grade book, calendar, chat and integrations, whether they used them or not. The awareness of these features tends to be correlated to the features used by their instructors; however, that assessment was not within the scope of this paper. Every feature was familiar to at least 31% of the students. The feature that had least student awareness was Chat/Instant Message; this feature had just 31.1% awareness. Table 6 summarizes the features and the percentage of students who indicated their awareness of the feature.

Table 6. Student Awareness of Blackboard Features

Feature	Percent Awareness
Comprehensive Email Too	63.9%
Notification System	52.1%
Multimedia, Graphics, Audio, Video	39.5%
Mandated Gradebook	76.5%
Course Calendar	60.5%
Chat Instant Messenger Tool	31.1%
Access to Class Roster	79.8%
Integration with other Systems (library, webmail)	42.9%

The last question on the survey related to research question #3 which asked the students to identify features that should be implemented in Blackboard that will enhance their learning

experience. Three students recommended improving its overall format and giving it "Skype like" features that include a webcam for visual interactions. Another student suggested a pictorial roster to enhance student and instructor communications.

Other feature improvements that were suggested involved functionality that can be readily controlled or changed within Blackboard. A total of nine students provided feedback in this category. The suggested improvements included removing unused options or tools, a cleaner interface, standardization, interactive feedback on homework and exams, a tutorial, and alerts on assignments and exams.

5. CONCLUSION

Online education can be greatly improved when a university maximizes the benefits that are offered by learning management systems such as Blackboard. The results section captured the benefits, drawbacks, and suggested improvements from the perspective of the students. It is essential to understand the student's perspective and perceptions if the university is to effect tool modifications that will enhance learning.

Many of the drawbacks identified by the students and many of the modifications suggested relate to the university's implementation of Blackboard. These changes included a cleaner Blackboard course interface without unused sections/options, a standardized Blackboard shell for all instructors, tutorials on using Blackboard, alerts for upcoming exams and assignments and interactive feedback on assignments and exams. The university can currently implement these features. The university can adopt standardized procedures and institutionalize a standard Blackboard course shell for all instructors. Additionally, the university can provide a video tutorial or just in time Camtasia/Captivate screen interactions for students and instructors. With adequate training, instructors can hide unused Blackboard tools and features to enhance the learning experience for the students. In some cases, it may be more effective to have the department or university as a whole develop a standard that the professors follow for teaching online courses.

On the other hand, some suggested features require software modifications to the Blackboard application. Two such areas of improvement are discussion board and rosters. The roster or student profile should be enhanced to allow the students to update additional information and to include a picture to their profiles. This will allow the students to connect better with their other peers in the classroom. Also, the discussion board should be enhanced to incorporate a webcam for interactive chat or discussions. Currently, the university would have to use third party tools such as Elluminate or Wimba to fill this gap. Blackboard, Inc. just initiated an acquisition of Elluminate, Inc. and Wimba, Inc. This acquisition could potentially address this suggestion in the next release of Blackboard. The effective implementation of the existing features in the online learning management system and the development of new features can improve community, critical thinking, and communications, and enhance the learning experience for the student.

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Towards an Innovative Web-based Lab Delivery System for a Management Information Systems Course

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Abstract

While online systems are an essential component of distance learning, they can also play a critical role in improving the delivery of activities in a traditional laboratory setting. The quality and effectiveness of online course delivery is often compared to equivalent face-to-face alternatives. In our approach, we have harnessed what we feel to be the best of both delivery methods. We have developed a web-based system with some novel characteristics for use in a face-to-face laboratory-based Management Information Systems course. To assess its impact, we surveyed 110 students where approximately half completed the lab using our web-based system while the other half completed a paper-based equivalent. The promising results have encouraged us to develop further experiments to measure student performance as well as the impact of video versus text in presenting activity instructions.

Keywords: web-based labs, management information systems, automated feedback, laboratory-based learning, blended learning

1. INTRODUCTION

Is the quality of delivering online course material equivalent to face-to-face alternatives? This is a persistent question in the field of instructional technology. Many studies show no differences between online and face-to-face course delivery. Disadvantages often cited for online delivery include lack of face-to-face interaction with instructors and social isolation (van Schaik, *et al*, 2003). Other studies have shown evidence of online delivery offering superior quality instruction when compared to face-to-face alternatives. Studies have demonstrated that online course delivery has been shown to keep students more engaged and even entertained, which often translates into a richer learning experience (Elsenhiemer, 2003).

The driving force behind many online delivery systems is shifting the control of learning from the teacher to the student (Junaidu, 2004). Online course delivery also provides opportunities for a more robust process of knowledge transfer, the process of synthesizing classroom theory into practical real life work

situations (Hansen, 2008). Practical application of topics taught is an overarching theme of our labs.

In our study, we propose a blended model of instructional delivery that maintains the focus on knowledge transfer and practical application for our students. We harness the benefits of online delivery systems, providing an entertaining and engaging environment that is conducive for knowledge transfer while also providing a social, face-to-face learning environment. We believe that this blended model combines the "best of both worlds," where students can work at their own pace, with automated, instant feedback and the opportunity to obtain guidance from an instructor.

Our goal is to improve students' learning experience by moving away from paper-based lab worksheets to a new web-based lab delivery system. Our previous system had detailed instructions but it was easy to inadvertently skip steps. Grading paper lab worksheets was very time consuming, and we suspect that sometimes students rush through the labs but were not learning key concepts. We seek to improve their lab experience by making the labs more interesting, reinforcing concepts as needed, while implementing a system for recording students' responses, reactions, and other feedback as a way to assess their progress. This allows us to focus on what skills or concepts the students need to learn, and improve our capacity for collaboratively developing and testing lab materials.

Our institution, course, and lab: We are a liberal arts college of approximately 3000 students with an AACSB accredited School of Business. Our Management Information Systems (MIS) course, a required core business course, is taught within the Computer Science department, which offers a BS in Computer Science and a minor in Information Systems. MIS is an introductory level course that requires students to have spreadsheet proficiency. The course consists of two hours of lecture and two hours of lab each week. Labs sections are restricted to a maximum of 16 seats where students typically work in pairs at a computer with dual monitors.

2. EVOLUTION OF OUR LABS

Before developing our web-based lab delivery system, we implemented a collaborative approach to scaling our MIS course to many sections (Breimer, *et al*, 2009). The material presented in labs is the driving force for integrating content and experience for the course. We created a shared repository of lab and lecture materials in Blackboard that fosters collaboration among faculty teaching the course. A faculty member can contribute new lab ideas and corrections using an editing review system, where at least two other faculty members must review the suggested changes and perform the lab in entirety to ensure continuity and cohesiveness.

Our labs have a "triad" structure that incorporates (i) theory from the textbook or lectures and (ii) practical case studies with (iii) information technology, such as Excel, Access, Geographic Information Systems, and Radio Frequency ID readers. Most labs have pre-lab reading assignments and an online quiz to introduce the lab. The in-lab experience is fast paced, where students are paired in teams to use technology and learn basic concepts to solve problems and to work through examples. Lastly, students individually complete a post-lab assignment to synthesize material and to reflect on the lessons learned in the lab.

The single printed lab handout: The original labs we developed consisted of a single lab handout, a Microsoft Word document. The lab handout included introductory text, activity instuctions, and questions appropriately embedded within the instructions. Many of the questions would ask about the output of an activity to help verify that students were properly completing each task. These questions might ask about the result of a database query or a spreadsheet function. Some questions required students to either show the instructor the output of key tasks (task checks) or to print and attach the output (deliverables). Towards the end of the lab, a few questions were designed to assess student learning. For example, we might ask about the purpose of a query or function, or we might ask the student to explain how the activity they just completed demonstrated a concept from the readings.

40,000 pages per semester: Our printed lab handouts were lengthy documents ranging from 20-35 pages. We wanted the activity instructions to be easy to read, so we were generous with font size, line spacing and logical pagination. The length of the handouts became problematic. With approximately 200 students each semester, the course was taxing the print shop with over 4000 pages per week. In addition, the instructors found it to be mechanically burdensome to page-through a 30-

page handout to find the answers to 20 questions.

Electronic instructions: To solve printing and grading problems, we removed the answer areas from the lab instructions and instead directed students to write their answers on a printed worksheet. Rather than print the lab instructions, students download and view the instructions electronically. Our computer labs have dual-monitor desktops, which enabled students to view the lab instructions on one display while performing tasks on the other display. The worksheets, which are the only documents printed, typically range from 3-6 pages and include only the questions and space for answers. This approach significantly reduced the amount of paper we used and created a concise worksheet, which was easier to grade.

Too many sources: While separating the lab handout into two documents (online instructions and printed worksheet) solved printing and grading problems, it may have come at a cost for students. In lab, instructors noticed that students struggled to find their place in the lab instructions. The labs now required students to manage three different sources of information. Students had to read the instructions (one source) and then switch to using an application (second source) to help answer questions on a worksheet (third source). Rather than return to the instructions, some students would continue on the printed worksheet and try to answer the next question without realizing that the instructions were necessary to help answer the next question. In returning to read the instructions, students would often lose their place. In some cases, students would start the same task again, not realizing that they had already completed the task; or even skip steps and fail to realize it until they hit a serious roadblock.

One source - web-based labs: We have long realized that the solution to our problem is to have entirely web-based labs where students submit their answers electronically within the online instructions. This has a number of advantages. First, it allows us to avoid paper documents entirely. Second, it allows close-ended or multiple choice questions to be graded automatically, which gives us the option to give students immediate feedback. Third, open-ended questions can be more easily graded in a batch format where the instructor can view all student answers to a particular question rather than all the answers for a particular student. Finally and perhaps most importantly, students do not have to switch from electronic instructions to paper worksheets, since questions will be embedded within the web-based instructions.

Solution is not obvious: We have considered using a number of different systems to support entirely web-based labs including the test management systems provided by Blackboard and Moodle (http://moodle.org). However, the systems that are readily available are missing key features and functionality that are important to our lab environment. Thus, we have been reluctant to invest the time to migrate our existing lab content into a system that may be inflexible, proprietary, or requires additional system administration. An ideal system would allow us to accomplish much of the migration process by simply saving our existing labs (Microsoft Word documents) into robustly formatted web pages (HTML documents) with the following features:

A. Question Embedding: A web-based lab system should allow questions to be embedded anywhere in a document. Many online testing systems are question-centered where only a single editable content area is provided for each question. Question-centered systems often prevent content from being placed both before and after each question on a single page. Our lab content includes formatted text, images, and will soon include embedded video/animation. A key requirement is the ability to place reinforcing content immediately before and after questions on a single web page.

B. Robust Pagination: A web-based system should allow a single page to contain two or more questions and allow two or more pages to be displayed in sequence without requiring a question on each page. Many question-centered systems present the entire test or assessment as a single web page or they require each question to be on a separate web page. These systems lack the flexibility to create documents with logical pagination. Unlike paper-based labs, which have fixed page size, web-based labs can have pages with variable page height, which enables documents to be broken into pages as needed by specific content requirements. Typically, systems that are question-based force the break at each question, which is very inflexible.

C. Inline Feedback: After a question is answered, a system should allow feedback to be dynamically inserted near the question. Inline

feedback should become part of the lab content after the question is answered. Many systems display feedback in a dialog box, which disconnects the feedback from the flow of the lab. Worse yet, feedback is lost once the dialog box is closed. Students should be able to return to previous pages and see the embedded questions, their answers, and the positive or negative feedback.

D. Temporal Tracking: A system should record a time stamp when a student views a new page or answers a question. Question-centered systems often only track students' progress from question to question. However, each page of a lab can be designed to represent a discrete task or activity. By tracking the time stamp of page views instructors can better understand how long it takes to complete activities, and make adjustments as needed.

3. OUR WEB-BASED FRAMEWORK

To implement the four features described in the previous section we use a very straightforward approach with a single HTML document. A single document approach greatly facilitates lab authoring and migration from our existing sources. Our paper-based labs were authored in Microsoft Word, and we can easily convert our existing formatted content by saving our documents as web pages. While Microsoft Word does not create the most elegant web pages, the result is quite usable.

The single document approach has two key advantages. First, the entire lab is portable and can be opened in an HTML editor such as Adobe's Dreamweaver or KompoZer (an open-source project) enabling robust editing and searching of the entire lab activity. In question-centered systems where the content is divided across numerous independent content areas for each question, searching for content across the entire lab or editing across different sections can be tedious and problematic. Second, after the single document is downloaded by the web browser, students can answer questions and navigate to pages without pages needing to be reloaded. We use JavaScript and simple tags to render the single document into pages. Upon loading, the first page is displayed along with navigation buttons to move to the next and previous page as well as a list so users can jump to a specific page number. Since the entire document is already loaded, navigating through the pages occurs instantaneously without the need to download content again from the server.

Rather than create an entire web application from scratch, we use PHP and JavaScript to enhance a basic HTML document. To transform a web page into an interactive lab, you simply insert two PHP function calls inside the <head> of the document (see Figure 1). For those not familiar with PHP and other web scripting languages, a PHP-enabled web server will execute the code inside of the PHP delimiters (<? and ?>) and return the output (result) rather than the code itself.

```
<html>
<head>
<? include("functions.php");
   create_lab("Lab Name or ID"); ?>
</head>

<body>

<h1>Lab Title</h1>

<p>Lab content formatted with
HTML</p>

</body>
</html>
```

Figure 1: Including the necessary code

For the code in Figure 1, the *include* and *create_lab* functions inserts all the necessary JavaScript code in order to embed interactive questions, add page breaks and dynamically generate the page navigation.

The web page must be hosted on a web server that supports the PHP scripting language. While the web server should also support a database system such as MySQL, our system can be easily adapted to use flat files to store the data.

Question Embedding: To embed a question, we implemented a set of PHP functions that insert the appropriate HTML and JavaScript code. Figure 2 shows the function declaration for creating a multiple-choice question. The function allows an author to specify the text of the question followed by an ordered list of possible choices as well as a number indicating which item in the list is the correct answer. Optionally, the author can specify feedback text to display if the answer is correct or incorrect.

```
string multiple_choice(
  string question,
  array choices, int correct_choice
  [, string correct_feedback
  [, string incorrect_feedback]] );
```

Figure 2: PHP function declaration for multiple-choice question

```
<? multiple_choice(
"Which day has the most employees?",
array("Mon","Wed","Thurs","Sat"), 4,
"Correct, Saturday has the most",
"Incorrect, are you using the proper
table?" ); ?>
```

Figure 3: PHP function call for creating a multiple-choice question.

Figure 3 shows a sample function call to embed a typical multiple-choice answer with both positive and negative feedback. Authors familiar with HTML code need only learn the parameters of the PHP functions to add interactive questions to existing HTML documents. For simplicity, we only show multiple-choice questions in our first web-based lab, but we have implemented functions to support a number of different question formats.

When the web browser requests the document, the PHP functions automatically generate and label the questions with sequential numbers. Questions can be removed, added, and re-ordered without the author needing to re-number questions. Figure 4 shows a basic web page with an embedded multiple-choice question at the bottom.

Inline Feedback: When a question is answered, the JavaScript code disables the submit button and optionally displays the feedback in a dynamic area next to the question. Different types of questions can be implemented to allow for multiple responses and multiple levels of feedback. The key feature is that the feedback is displayed inline with the question. The jQuery library (McCormick & De Volder, 2004) is used to animate the feedback display. In our implementation, the feedback text fades-in as the submit button disables (see Figure 5).

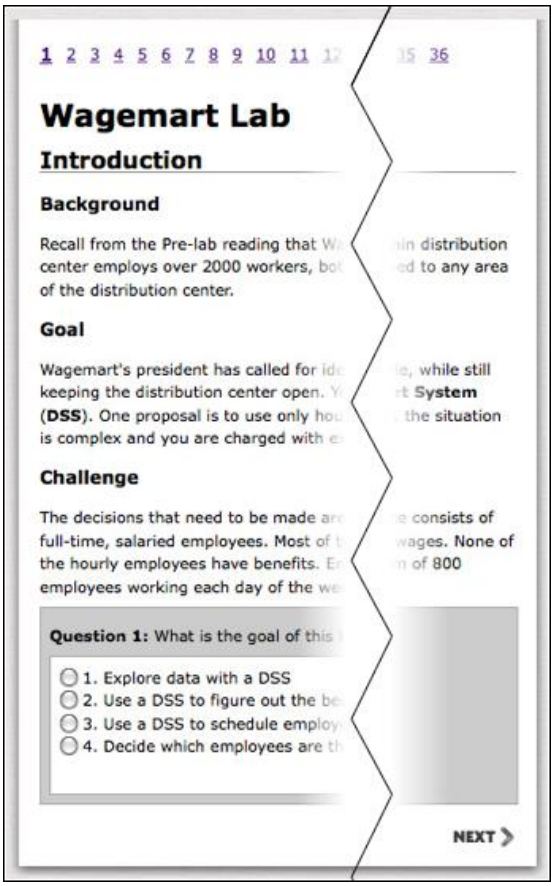

Figure 4: Example page with embedded multiple-choice question

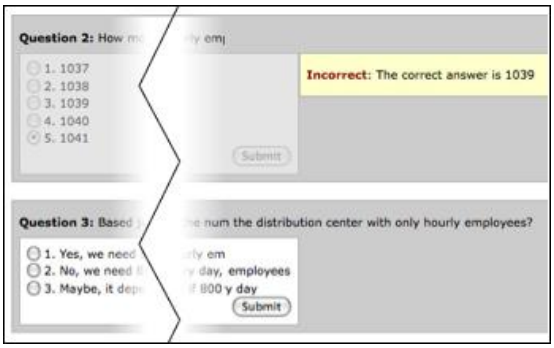

Figure 5: Answered question with inline feedback and un-answered question.

Page Navigation: In standard HTML, the *body* tag indicates the start and end of the displayed page. However, a single HTML document can be broken into logical divisions where Cascading Style Sheets (CSS) and Document Object Model (DOM) scripting can be used to display each

division as a page. Figure 6 shows our approach to breaking a single document into multiple pages.

```
<body>
<? startNavigation(); ?>

<h3>First Page</h3>
<p>HTML formatted content</p>

<? pageBreak(); ?>

<h3>Another Page</h3>
<p>More content</p>

<? pageBreak(); ?>

<h3>Last Page</h3>
<p>More content</p>

<? endNavigation(); ?>
</body>
```

Figure 6: Breaking a single document into multiple pages

The *startNavigation*, *endNavigation*, and *pageBreak* functions insert appropriate HTML tags that encapsulate each logical page into structural divisions that can be controlled by the inserted JavaScript functions in the *head* of the document.

We use JavaScript to count the number of pages/divisions and then dynamically generate navigation that allows the user to move from page to page. Figure 4 shows the page number navigation at the top and the "Next" button located at the bottom of the page.

In our particular implementation, we arrange each page horizontally but hide all the pages except the one being currently viewed. The navigation triggers JavaScript functions that slide the pages left and right appropriately. The left and right sliding is designed to give the user a visual cue that they have moved to a new page. Moving right will bring users to the next page, while moving left will bring them to the previous page. Because the pages have variable height, the user must often scroll up or down to view the content of a particular page. Thus, we did not want to use sliding up or down as a metaphor for moving to a new page as it can be easily confused with typical page scrolling.

Temporal Tracking & Submission: The JavaScript code uses the AJAX web development framework (Garrett, 2005) to asynchronously transmit the user's response to any server where the student responses can be recorded in a database or log file. Each response includes the question number, the local time stamp, whether or not the submitted answer was correct, and the user's name or ID. The time stamp is generated using the JavaScript *Date* and *getTime* functionality. Since question submission does not require a synchronous server response, the time stamp reflects the instantaneous local time without any delay from network lag or server load. Our system also has the ability to transmit a time stamp each time a user clicks a navigation link. The page number and the time stamp can be used to better understand how long it takes to complete the activity described on each page. Thus, the pagination can be adjusted to reflect discrete tasks or activities that the instructor would like timed.

Our PHP submission script can be configured to work with an independent login or authentication system. The submission script will only store the user's response if the user's browser transmits a cookie- or URL-stored session ID that matches the server-side session ID established by the login or authentication script. While we've implemented our own email-verified registration and login system, a number of existing frameworks can be used to implement authentication. If an instructor does not wish to record student responses, the lab can act as a stand-alone interactive activity with dynamic feedback that does not record student IDs or responses.

4. PROTOTYPE TEST AND STUDENT IMPRESSION SURVEY

Overview: To test our system, we converted one of our existing labs into the web-based format by saving the Word Document as a web page and inserting all the appropriate tags to embed 40 questions. This particular lab requires students to create and execute a series of Microsoft Access queries that act as a simple decision support system (DSS) to help a fictional company cut labor costs. The lab is designed to help develop student database skills such as creating select, action and summary queries, as well as joining tables and creating calculated fields. The lab covers the concepts of decision structure, scenario and data modeling, and decision optimization.

We administered the paper-based lab in four sections (52 students) and the web-based lab in four different sections (58 students). Immediately after the lab session, we surveyed all 110 students in the 8 lab sections to assess their impression of the lab they just completed.

Five different instructors taught the eight lab sections. Three instructors each taught two labs and these instructors administered the web-based lab to one of their sections and the paper-based lab to their other section. Two instructors each teach one lab and one of these instructors administered the web-based lab while the other administered the paper-based lab.

Q1.	How long did it take you to do this In Lab work? Rate 1 (very short) to 10 (very long)
Q2.	How difficult did you find the work for this Lab? Rate 1 (very easy) to 10 (very hard)
Q3.	How would you rate the level of feedback you received in lab? Rate 1 (no value) to 10 (great value)
Q4.	How easy was it to keep your place and follow Lab procedures using this lab format? Rate 1 (very easy) to 10 (very hard)
Q5.	How much did this Lab help you understand what is being studied in this course? Rate 1 (very little) to 10 (very much)
Q6.	How did the lab format affect how easy it was to keep your place and follow the lab procedures? Rate 1 (very easy) to 10 (very hard)
Q7.	How much did you enjoy the activities in this Lab? Rate 1 (very little) to 10 (very much)

Table 1: Survey Questions

The Results: Table 1 shows the exact wording of each question. Table 2 shows the mean and standard deviation for students who completed the paper-based lab and web-based lab. Table 3 shows the probability of the null hypothesis of no difference between the groups for the t-test (T) and the Mann-Whitney test (U). Although many researchers use the t-test for Likert scale data if the sample sizes are large enough (over 30 or so), the Mann-Whitney statistic is designed for ordinal (ranked) data to compare unpaired groups (Motulsky, 1995). Statistically significant differences between the two datasets correspond to T and U values below 0.05.

The data indicates a very slight but insignificant favoring of the web-based lab with respect to both perceived length of the lab (Q1) and the value of the feedback (Q3). There was no meaningful difference in perceived difficulty (Q2). Interestingly, students did not think that the web-based lab made it easier to keep their place and follow the lab procedures (Q4). However, the difference in question 4 was not significant and a similarly worded question (Q6) showed the opposite where the web-based lab was easier to follow.

Question 5 was indicated as being significant by t-test but not by the Mann-Whitney test, indicating mild favoring of the web-based lab for helping students understand the course material, but this concept should be investigated further. Question 7 definitely indicates a statistically significant difference favoring the assertion that students found the web-based lab to be more enjoyable than the paper-based lab (Q7).

	Paper-Based Mean (STD) n = 52	**Web-Based Mean (STD) n = 58**
Q1.	7.92 (1.92)	7.31 (1.85)
Q2.	7.40 (1.90)	7.10 (1.86)
Q3.	6.69 (2.37)	7.35 (2.10)
Q4.	5.90 (2.61)	6.45 (2.45)
Q5.	5.65 (2.69)	6.62 (2.14)
Q6.	6.08 (2.27)	5.81 (2.35)
Q7.	4.56 (2.63)	5.72 (2.44)

Table 2: Means and standard deviations

	T	**U**
Q1.	0.091	0.069
Q2.	0.400	0.386
Q3.	0.130	0.157
Q4.	0.260	0.239
Q5.	0.039	0.070
Q6.	0.550	0.678
Q7.	0.018	0.022

Table 3: Statistical differences

Analysis: The paper-based lab format provided no built-in feedback at all, so it is surprising that there is no significant difference in students' perception of the value of the feedback (Q3). However, the paper-based format may in fact encourage students to check with the instructor for clarification and assurances. Students who completed the paper-based lab may have considered their interaction with the instructor when evaluating the level of feedback. Also, students who completed the web-based lab may have interacted less with the instructor than they normally do and this lack of instructor feedback could impact the perceived quality of the overall feedback received.

Prior to the experiment, students had already experienced six paper-based labs and had become quite accustomed to the format. Students who experienced the web-based lab for the first time may have lost their place because of the abrupt change in lab format, not necessarily because the web-based format was more disorienting. In the future, we are going to consider conducting similar experiments earlier in the semester before students become accustomed to the paper-based lab format.

The increased enjoyment (Q7) that students experienced with the web-based lab was statistically significant with a P=0.018 and U=0.022. Based on in-lab observations, the anticipation of immediate feedback certainly had a positive impact on students. Students received immediate assurances about whether the task they completed was correct or incorrect. In the paper-based lab, students experienced great frustration in discovering a task error after moving forward with dependent tasks. This often occurred because the instructor was not readily available to provide clarification or feedback to all students. The automated feedback provided by the web-based lab allowed students to more quickly correct errors before moving forward with incorrect results and data. Thus, students seemed to make fewer mistakes and perhaps perceived that they were learning more (Q5). While students may not have explicitly valued the feedback, it may ultimately contribute to a more successful and more enjoyable lab experience.

5. CONCLUSION & FUTURE WORK

Our preliminary experiment showed that students had a more favorable impression of the web-based delivery compared to the paper-based delivery. Interestingly, we saw contradictory results when two similar questions about keeping place and following the instructions were asked. We had hoped that by eliminating the paper-based worksheet we could create a lab process that was easier for students to follow. While student impressions did not improve in this area, the web-based lab received more positive impressions in two critical areas, enjoyment and, to some extent, understanding of material. We believe that providing automated feedback is the critical advantage of the web-based system.

In a face-to-face environment it is unrealistic to assume the instructor can provide feedback to many students in the same timely manner as an automated system. While some students may still prefer asking the instructor for clarification or assurance, the web-based system provides great advantages in a face-to-face environment. The system helps free the instructor to spend even more time with students who prefer face-to-face interaction while those who are satisfied with automated interaction can move through the lab without having to wait for feedback. Aside from some anxieties about switching to a new system, the instructors found the web-based labs to also be more enjoyable and successful.

Finally, we found it rewarding to implement our own system using standard JavaScript and basic PHP code insertion techniques. The most time consuming aspect of creating interactive labs is creating the content or migrating the content into inflexible online testing systems. In our approach we did not have to convert our content into the format of question-centered testing and content management systems. Instead, we could literally save our existing Word document as a web page and simply insert page breaks and question generating functions.

The Next Step: Our system is still very experimental and our results are preliminary. The next step is to assess the impact of the web-based system on student performance, i.e., how accurately do students answer questions and how quickly do they complete tasks. In our preliminary experiment, we were unable to compare student performance because of variation in the question format between the paper-based and web-based questions. To avoid technical problems and for simplicity of grading, our proto-type system used only multiple-choice questions. However, we did not have time to convert all the questions of the paper-based lab to multiple-choice. Given the difference in question format, we could not fairly compare

student grades (paper-based vs. web-based). We plan to re-run the experiment with identical questions for the two lab formats.

Also, we were unable to precisely compare completion times of web-based vs. paper-based because of the obvious task tracking limitations of the paper-based format. However, our web-based system provides the perfect environment for comparing possible differences in performance and completion time given different kinds of web-based content, namely text-based instructions vs. video-based instructions.

The next step will include the integration of video instruction into the online system. Our hypothesis is that the video delivery will provide a richer, more meaningful method when compared to just text and images. Building on research demonstrating the positive benefits of using video, we plan to test if video-based instruction provides greater acquired practical skills and superior application or craftsmanship of skills taught in our labs (Donkor, 2010).

For our future research, we will again divide our students into two groups - four sections will receive the online video-based lab and four sections will receive the online text-based lab. All sections will use the same online delivery system with identical questions. The only difference will be the presentation of the content (i.e. video instructions vs. text instructions).

After the viability of including video with the on-line instructions has been demonstrated, we plan to develop a collaborative model where a team of instructors can contribute to the system content and video delivery. We strongly believe that a content delivery system should facilitate collaboration among instructors to achieve a synergistic effect. Instructors should be able to add and modify content without a restrictive approval system. We plan to develop an authoring environment so that expertise in PHP is not required for course development.

Labs should be dynamic, so that additional help or questions can be provided based on previous responses. The flow of content should be easily mapped using the authoring environment. We also envision providing functionality for students to report problems and rate content as they perform the lab - was this section clear? Did you learn from this module? Did you like the way concepts were presented? This gives course developers immediate feedback on potential problems and opportunities for improvement.

Our continued challenge is that we as teachers need to formalize the concepts and to develop good tools to assess whether or not students truly learn these concepts. To this end, careful attention to lab design will be incorporated to ensure that the core concepts are presented in measurable ways that improve students' retention of these concepts.

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Computer Ethics: A Slow Fade from Black and White to Shades of Gray

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Abstract

The expanded use of teaching case based analysis based on current events and news stories relating to computer ethics improves student engagement, encourages creativity and fosters an active learning environment. Professional ethics standards, accreditation standards for computer curriculum, ethics theories, resources for ethics on the internet, and possible topics for ethical case analyses are presented. The motivation for teaching Cyber Ethics and a number of success strategies and recommendations for undergraduate Computer Ethics courses are provided.

Keywords: ABET Accreditation Standards, Computing Curricula 2001(CC2001), Professional Code of Ethics, Computer Ethics, Cyber Ethics, Computer Science, Information Technology, Computer Information Systems, Pedagogy, Computers and Society.

1. INTRODUCTION

The Accreditation Board for Engineering and Technology (ABET) has nine common outcomes which apply to Computer Science (CS), Computer Information Systems (CIS) and Information Technology Programs (IT). Computer Ethics is one of these nine outcomes and graduating students must have an understanding of professional, ethical, legal, social issues and responsibilities (Homkes & Strikwerda, 2009).

In additional to satisfying the accreditation standard, an undergraduate CS or CIS course must engage the students and encourage analytical thinking, creative writing and research. Students in the Engineering and Technology fields are problem solvers who typically look for a single solution (i.e. the code is working or the answer to an equation). Thus, the teaching of Ethics must broaden the student's perspectives and understanding of certain real world scenarios, which have no absolute correct answer but rather multiple viewpoints and opinions. For example a current event topic such as the Chinese Censorship of Microsoft and Google, has the Chinese Government attempting to police and control information provided to the general public, which is contradictory to the freedom of the press and free speech values of American Society (Chao, 2010).

This paper describes the course format for an Undergraduate CS/CIS course taught at the University of Michigan Flint. The paper presents the basic goals and objectives of the course, the motivation for teaching such a course, the relevant codes of ethics, ethic

theories, overview of topics covered, grading rubrics and additional resources for teaching Computer Ethics. A number of success strategies and recommendations for teaching undergraduate Computer Ethics are also provided.

2. COURSE GOALS AND OBJECTIVES

This course introduces students to the ethical issues and controversies that comprise the new field of Cyber-Ethics. The field of Cyber-Ethics refers to the broad spectrum of computing and information technology ranging from hand held devices, stand-alone computers, privately owned computer networks and the public internet. Issues addressed examined the moral responsibility of computer professionals in the broader context of social and ethical applications of information systems and computer technology.

In this course, students were discussing ethical challenges and ethical controversies using actual case examples and contentious scenarios to illustrate the various ethical dilemmas and various stakeholder viewpoints. In contrast to traditional science and engineering, ethical issues and cases do not have clear-cut straightforward solutions. Hence, it is important to look for strategies, stakeholder interests and different viewpoints of each stakeholder for analyzing these issues. Students must learn to examine topics from a variety of perspectives that sometimes conflict with each other (Dark, et al., 2008). The course was designed to encourage student creativity, student engagement, research and writing skills.

Motivation for Teaching Ethics

The ABET accreditation requirements state that the program of study "enables the student to achieve, by the time of graduation:

- An understanding of professional, ethical, legal, security and social issues and responsibilities.
- An ability to analyze the local and global impact of computing on individuals, organizations and society" (Homkes & Strikwerda, 2009).

The IEEE-CS/ACM Joint Task Force on Computing Curricula recently mandated the inclusion of sixteen core hours of instruction on topics that are *social*, *ethical*, and *professional* in the curriculum for undergraduate computer science students. These topics, each prefaced with an *SP* designation, define one "knowledge area" or a "CS body of knowledge." They are distributed among the following 10 units:

- SP1: History of computing
- SP2: Social context of computing
- SP3: Methods and tools of analysis
- SP4: Professional and ethical responsibilities
- SP5: Risks and liabilities of safety-critical systems
- SP6: Intellectual property
- SP7: Privacy and civil liberties
- SP8: Computer crime
- SP9: Economic issues in computing
- SP10: Philosophical frameworks of ethics (Tavani, 2002)

Of particular interest to ethics instruction *per se* are the methods and tools of analysis (SP3) which provides students with instruction on how to make and evaluate ethical arguments, and then identify and evaluate ethical choices (Tavari, 2002). Among the topics recommended for inclusion in SP 10 are instructions on philosophical frameworks that include deontological and utilitarian theories.

Currently there is a joint committee called Computing Curricula 2001 (CC2001) involving the Association for Computing Machinery and the IEEE Computer Society, which is producing curriculum guidance for the broad area of computing. The purpose of CC2001 is to evaluate future developments in computer engineering in the next ten years (2013) and beyond. The CC2001 Task Force was asked to develop a set of curricular guidelines that would match the latest developments of computing technologies and endure through the next decade. Principle 10 from the CC2001 Task Force states:

"The computer engineering curriculum must include professional practice as an integral component of the undergraduate curriculum. These practices encompass a wide range of activities, including management, ethics and values, written and oral communication, working as part of a team, and remaining current in a rapidly changing discipline" (McGettrick, et al., 2003, p. 9).

In addition to the requirements of the ABET accreditation standards and those of the IEEE-CS/ACM, an understanding of ethics is particularly important to Computer and IT students due to the ubiquitous nature of computers, information technology, web systems and internet applications in our daily

lives. Computer applications and information systems are used by people to drive cars, control life preserving and life taking devices, and affect many daily functions from banking, shopping, entertainment, education, etc. Computer and Information Systems are a critical component of our society and citizens and customers do not and cannot be expected to understand the systems on which they depend for vital life functions (Johnson, 2007).

Computer professionals must act in a socially responsible and ethical manner to be worthy of the public trust. The special talent and knowledge required for developing and managing these IT systems leads to a social responsibility to use it for the good of society (Reddy, 2004). Students need to think about the consequences of their professional decisions, evaluate their actions in terms of their social responsibility and the long-range ethical impact.

Relevant Codes of Ethics

The ACM code of ethics and the IEEE code of ethics are presented in the course to expose students to the broad social consciousness of "Cause No Harm" and in cases where there is low quality work or potential for dangerous outcomes, it is your responsibility to act positively to rectify the situation (Reddy, 2004). The original ACM code of Ethics and Professional Conduct stated, "An ACM member shall consider the health, privacy and general welfare of the public in the performance of the members work. An ACM member, when dealing with data concerning individuals, shall always consider the issue of individual privacy and seek the following: to minimize the data collection; to limit authorized access to data; To provide proper security for the data; to determine the required retention period of the data; to ensure proper disposal of the data" (Landau, 2008).

The current ACM code of ethics is presented and compared to the code of ethics from two different IT professional societies as shown in Appendix I.

The institute for Certification of IT Professionals (ICCP) uses a code of ethics to emphasize high standards of skill and knowledge, the maintenance of confidentiality, and that the IT professional will recognize the public reliance upon the standards of conduct and established practices. The Association of Information Technology Professionals (AITP) has a code of ethics that encourages members to:

- Promote management's understanding of information processing,
- Act with honesty and respect,
- Participate to the best of their abilities in the distribution of IT knowledge,
- Protect confidential knowledge,
- Uphold the ethical and moral principles of educational institutions,
- Practice trust to their employers to guard the employer's interests and
- Respect their countries and the chosen way of life of those countries (Brinkman, 09).

The seven values or key concepts comprising any code of ethics are consistency, respect for individuals, autonomy for all, integrity, justice, utility and competence (Panye & Landry, 2006).

Challenges

This is a major thought process shift from the traditional software development methodology of merely writing code and solving problems (Reedy, 2004). It is challenging to have undergraduate students understand the importance of ethics and professional responsibility. Hence, the notion of what is professionally acceptable and good in computing and information systems is best illustrated by examples and case studies. The use of major catastrophes such as the European Agency Ariane 5 rocket, which crashed on June 4, 1996, 37 seconds after liftoff and cost about $500 million provides an attention grabber that undergraduate students can understand. The software flaw was a simple computational error of converting a 64-bit integer into a 16 bit unsigned integer, without any exceptional handlers for errors (Jėzėquel, Meyer, 1997).

3. PEDAGOGY

The Course CIS/CSC 150 is a one credit course, taught at the undergraduate level over a period of twelve weeks with class periods held alternating weeks for a total of six class periods. The first two class periods provide lecture material and discussion material from the textbook, to provide ethical theories, definition of terms such as ethics, morality, rules of conduct, moral system, critical thinking skills and the basic structure and strength of logical arguments. The other class periods are devoted to student's discussion of their case study

assignments, current events and news stories relating to computer ethics.

Top Down Teaching Approach

The division of the course by including both the theoretical foundation from the textbook and the use of case studies is beneficial since it includes both the top down and the bottom up approaches for teaching computer ethics. The top down approach to ethical thinking evaluates a social and/or moral problem by applying the universal principle based upon several important ethical theories. These ethical theories are covered in popular textbooks of Basse, Johnson, Quinn, Spinello and Travani and present theories including Kantianism, utilitarianism, rights based theories, social contract theory and virtue ethics (Quinn, 2006).

The text *Ethics and Technology Ethical Issues in an Age of Information and Communication Technology* by Travani was utilized by this course to present the different ethical theories and critical thinking skills. Cyber ethics is a branch of applied ethics examining practical ethical issues and performing analysis of specific moral problems by the application of ethical theories. Ethical theories such as utilitarianism, which provides the greatest good for the greatest number of people are presented. Other ethical theories covered in class include:

- Character Based Ethical theory or Virtue ethics focuses on decision criteria based upon the character development of individuals and their acquisition of good character traits and habits (Tavani, 2007).
- Kantian analysis requires that the actor treat everyone the same and it requires that the actor would find such treatment acceptable if visited upon himself. The action to be undertaken must respect individuals as valuable, and the person acted upon is due respect. The autonomy of all persons and their freedom to make voluntary and informed choices must be recognized. Kantian ethics can be reduced to something approximating the well known "Golden Rule" (Panye & Landry, 2005).
- Duty Based or Deontological theories, which argue that morality must be ultimately grounded in the concept of duty or obligations that humans have to one another (Tavani, 2007).
- Utilitarianism theory, which is based on the principle of social utility or social use-fulness measured by the amount of happines produced (Tavani, 2007).
- Contract-Based theories where individuals surrender some of their absolute freedom in return for a system of laws and regulations, which are designed to protect individuals from being harmed by other members of society (Tavani, 2007).

Critical thinking skills and criteria for determining and differentiating among arguments that are sound vs. unsound, valid vs. invalid, and inductive vs. fallacious, and a strategy for evaluating the overall strength of reasoning were also covered.

Bottom Up Teaching Approach

The second approach used for teaching this class is the bottom up methodology utilizing a case study approach, based upon the student's research and written assignment. Each student was instructed to select two cases from the textbook and two cases from the own research sources. The last four class periods were devoted to student discussion of their four written assignments.

Unfortunately, textbook topics for ethics classes typically deal with topics that Information Technology (IT) and Computer Information Systems (CIS) students will not personally experience and cannot relate to such as bribing a purchasing agent, insider trading, or illegal corporate activities. To engage students in ethical discussions, case studies and topics which students deal with on a daily basis and have personal experience with are more interesting and relevant (Sherman, 2007).

All students were presented with the following assignment requirements at the first class meeting. Students read the Wall Street Journal, Business Week, Information Week and other references cited in the Textbook or IT trade journal publications and prepared a research report. The research report was on current Cyber ethics issues such as privacy, security, electronic monitoring of employees, collection and use of personal information on consumers, identity theft or other ethical topics related to course material.

Grading Rubrics

The grading rubric for the assignment was based upon the author's research and was adopted from the In-Depth Case Analysis Rubric Media file EE_FinalRubric_S06.doc, found on the web site: *Rubrics for Exams and Group Projects*

in Ethics, located at the web site http://cnx.org/content/m14059/latest/. This original grading rubric provides an assessment for a final case analysis report that is based on the Social Impact Statement Analysis described by Chuck Huff at www.computingcases.org.

The actual grading rubric utilized in this course is a simplified version of the In-Depth Case Analysis. The grading rubric encouraged students to identify the ethically relevant facts and provide a summary of ethical issues in the case. Stakeholder's opinions, their different viewpoints and potential conflicts were to be identified by students, who also had to justify their claims using ethical arguments. The report was also evaluated for how well the student correctly applied problem categories (disagreement, & conflict) to classify the ethical components and uncovered the ethical issues that are embedded in complex, concrete situations. The last criteria of the grading rubric assessed the writing style, format, grammar and references of the report. The grading rubric is shown in Appendix II.

4. ETHICS WEB RESOURCES

There are many academic resources and web site resources available on the topic of computer ethics. The U.S. National Academy of Engineering (NAE) has a Center for Engineering, Ethics and Society (CEES, http://www.nae.edu/ethicscenter) which was launched in 2007. The CEES also manages the Online Ethics Center (OEC) at the NAE (http://www.onlineethics.org) to provide students and professionals in engineering and science the required resources for understanding and addressing ethical problems that arise in their work and to promote learning and advancements in the understanding of responsible research and practice (Hollander, 2010).

The http://www.onlineethics.org site is made possible by a generous grant from the National Science Foundation in response to the American COMPETES Act to improve resources for ethics in science and engineering education. The CEES at the National Academy of Engineering and the Ethics Education Library (EEL) at the Center for the Study of Ethics in the Professions at the Illinois Institute of Technology are working together on this project.

Charles Huff, Department of Psychology, St. Olaf College has a long standing research interest in identifying and evaluating ethical professional behavior. His seminars and related topics can be accessed from https://www.stolaf.edu/people/huff/links/links.html Additional relevant web sites for ethics and related information can be found in Appendix III.

An interesting approach for navigating across the different cyber ethic topics is provided by Dr Edward F. Gehringer who has posted a geographical site map with active hyperlinks to various cyber ethics topics and related issues on the site http://ethics.csc.ncsu.edu/ The Ethics in Computing Site Map is shown in Figure 1.

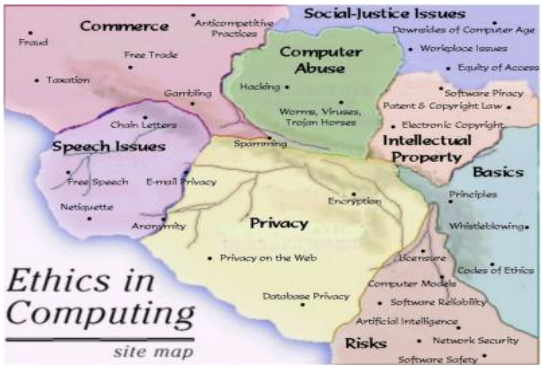

Figure 1 – Ethics in Computing Site Map

5. RESEARCH SOURCES

Students were initially provided with the following potential list of topics for their research:

- Types of Crime aimed at IT Systems: Viruses, Spyware, Phishing, etc.,
- Security Measures: How good they are, what they cost, how do they protect computers, how expensive are they to implement?
- Electronic monitoring of employees.
- Collection and use of personal information on customers/consumers (i.e. Wal-Mart)
- Identity Theft.
- Wireless Networking Hacking and Vulnerability, including detection and prevention measures.
- Unethical uses of email, and internet usage, such as spam, chain letters.
- Computer viruses include detection and prevention measures.
- Privacy Laws - Homeland Security, Freedom of Information Act, Family Education Rights and Privacy Act, HIPPA, etc. List the pros and cons arguments on the legislation, does

it protect national security vs. invade personal privacy?
- European Directive on Protection of Personal Privacy.
- Breach of Information - TJ MAX, Bank of America, Lexis Nexus, DSW Shoe Store
- Cyber Bulling/Cyber Stalking, research the case of Megan Meiers.

Reference articles were also posted on Blackboard™ as shown in Appendix II. These topics and articles were used to "jump-start" class discussions, and provided real world, current events for Cyber Ethics. Class discussions of these reference articles fostered the idea of critical thinking and identification of multiple viewpoints by dividing the class into separate groups and allowing each group to voice their viewpoint and then understand and respond to the viewpoints of the opposing stakeholders.

Student Motivation with Music

The initial approach to getting students engaged and participating in a discussion of ethical issues that student have experienced was to start by playing the song "It is a slow fade" by Casting Crowns. The music lyrics are (Casting Crowns, 2010):

"It's a slow fade when you give yourself away
It's a slow fade when black and white have turned to gray
Thoughts invade, choices are made, a price will be paid
When you give yourself away
People never crumble in a day

The journey from your mind to your hands
Is shorter than you're thinking
Be careful if you think you stand
You just might be sinking"

The song was used to stress the point that ethical dilemmas are not just black and white but have shades of gray since there can be a dichotomy of decisions all of which have rational judgments. Students were asked to provide examples from the personal experiences of ethical challenges. One student shared his experiences working for the Department of Defense. There was a new security policy implemented which prevented employees from accessing the public internet. This was done to minimize the lost productivity and time spent by employees on non-government related work. Unfortunately, once the new security policy was implemented, the purchasing agents could no longer perform their job function of searching for the lowest cost supplier and accessing the supplier web sites.

Identity Theft Role Playing

The case of the T. J. Max Credit Card Breach was utilized to foster student engagement and encourage the development of different stakeholder viewpoints. The Article was presented to the class stating that in 2005 TJX reported at least 45.7 million cards were exposed, while banks' court filings put the number at more than 100 million, but there has been no estimate of the total fraud. In 2007 TJX was the subject of a class-action law suit seeking "tens of millions of dollars" by The Massachusetts Bankers Association, which represents 207 financial institutions (Gaudin, 2007), (Shain, 2007).

Students were divided into different groups and then asked to voice their viewpoints as the consumer, the CIO and IT department managers of T. J. Max, or the Bank Association that is suffering financially from the stolen credit card losses. The consumer group voiced outrage over the negligence of T. J. Max to allow the security breach to go undetected and having it continue for such a long period of 18 months. The T. J. Max CIO and IT department managers stated that they had followed all the correct government rules and regulations and had standard security practices in place, hence they were not liable and should not have to settle the class action suit. The Bank Association was insistent that financial compensation be awarded in the class action suit to compensate for their financial losses.

The T. J. Max role playing scenario had reasonable arguments on all three sides, the consumers, the company, and the banking association. There was no "unarguably right answer". Students on each side needed to be able to explain why their side was "correct" and how to disagree with the other stakeholders (Brinkman, 2009). The role-playing of different stakeholders allows the students to actually experience the issues from a real world perspective rather than passively receiving it (Pollard & Duvall, 2006).

6. OVERVIEW OF TOPICS COVERED

The submitted student's reports covered a very diverse number of computer ethics topics and

were very original and innovative in some of the topics selected. Some of the major topics are:

- Identity Theft
- Internet Crimes and Computer Security
- Cyber Bullying/ Cyber Stalking
- Wireless Hacking
- Internet Bandwidth Throttling
- RFID Tags
- Employee Monitoring
- Search Engine Privacy
- Chinese Government Censorship of Google/Microsoft
- Customer Relationship Management
- Homeland Security/Airport Security
- Internet Music & Intellectual Property
- *HIPPA Records* Electronic Medical Records
- Software Piracy
- Privacy Rights in Web Based Advertising

Detailed ethical issues regarding these topics can be found in Appendix V.

7 INTERESTING, AND CONTROVERSIAL CASES

Cyber Bullying

Cyber bullying is increasingly prevalent in modern youth, and a recent survey has shown that 43% of teens in the United States experienced a form of Cyber bullying in 2008. In contrast, Canadian middle school children reported that 23% have been bullied by email, 35% in chat rooms and 41% through text messaging (Wagner, 2008).

One of the most recent and well-publicized cases of Cyber bullying is that of Megan Meier, a 13 year old girl from Missouri. An older neighbor, Lori Drew, impersonated a teen-age boy on the social networking site MySpace. Assuming the persona of a teen-age boy friend Mrs. Drew wooed and then rejected Megan. The MySpace postings by Mrs. Drew resulted in Megan committing suicide by hanging herself in her closet.

Lori Drew was recently convicted of misdemeanor charges (Surdin, 2009); however on July 2, 2009 the U.S. District Judge George Wu acquitted her on the basis "that charges of computer hacking are best left up to a website owner to determine what is a crime" (Zetter, 2009).

Regrettably, no additional charges are able to be brought against Drew, since this type of harassment was not yet covered by any existing state laws. Subsequently, in July 2008, Megan's home state of Missouri passed a bill that "updates state laws against harassment by removing the requirement that the communication be written or over the telephone." The new bill now covers harassment from computers, text messages and other electronic devices (USA Today, 2008). The movement to punish Cyber bullying quickly gained momentum and by 2009, 13 states has passed similar laws (Surdin, 2009).

Remotely Accessed Webcams

Allegations are being made against the Pennsylvania Lower Merion School District that the school was using laptop computers, which were loaned to students to spy on them. The spying could be done by covertly and remotely activating the webcams on the laptops. The school officials claim that the remote activation of the webcams is a tracking device utilized to recover stolen laptops. The installation of the LANRev Trojan on all the loaned out laptops allowed the school to run scripts to monitor the laptop usage, ensure proper operation and to possibly halt what was being accessed.

Parents and students learning of the remote activation of webcams followed up with a lawsuit based on the fact that the software was being utilized without prior consent of the parents and students. "As the laptops were routinely used by students and family members while at home, it is believed that many of the images captured and intercepted may consist of images of minors and their parents or friends in compromising and embarrassing positions, including but not limited to, various stages of dress or undress" (Claburn, 2010).

The main issue for the students and parents is privacy and their need to be protected from being spied on while in their homes.

8 COURSE RESULTS

Student Evaluations

Students were encouraged to provide comments, suggestions and feedback anonymously during the last class period. The student's written feedback and comments included the following:

"I never realized the ethical aspects of computers and technology before this class. Now I can distinguish an ethically wrong situation from a right one."

"Class was very interesting. I found that the subject of ethics is much more involved than I had originally thought".

"I liked the in-class discussions. Good class overall".

"I learned a lot in this course and enjoyed the discussions and learned more from discussions than the lectures".

"The course was very beneficial to me in understanding the scope of computer ethics, and the course format was good".

"I learned that I can learn a lot from my fellow students and I appreciate their opinions. I learned how to open up in the class discussions and found that there were other techies like me who like the same subjects."

"I learned about current events for computer and technological advancements and what should be done for control and enforcement of it".

"Great Class, well taught, manageable workload. I learned a lot about the subject and enjoyed the class discussions".

"Work load of four assignments was reasonable for a one credit course"

"Keep the relaxed nature of the class atmosphere. It is a break from the monotonous text book centered learning".

"I thought the class was great".

Other students provided the following suggestions for improvements:

"I would suggest one group project to help people think about ethics problems with more dimensions".

"Class meetings every week would be better".

"An improvement would be post more articles and topic selections."

"Provide more coverage of ethical principles and theories".

9. SUMMARY AND CONCLUSIONS

Professional practice of Computer Science and Information Technology consists of both technological knowledge and the skillful application of that knowledge guided by ethical standards

(Gotterbarn, Miller, 2009). The course utilized case studies to illustrate the tradeoffs between technical issues, legal issues, economic issues, stakeholder interests and ethical principles. This paper provided many useful resources such as an overview of ethical theories, pedagogy, research topics, web sites, and grading rubrics.

The Megan Meier case illustrated that legal and policy systems simply have not kept up with the changes to technology and latest ethical challenges such as Cyber Bullying. Other examples where the legal and policy system have not kept up with the challenges of misusing technology are illustrated with the rising problems of identity theft, phishing attacks and other means of defrauding the gullible public such as charity web sites, which are frauds. Students need to understand the legal solutions to ethical issues and develop appreciation for when the legal solutions address the ethical problem and where the legal solutions fall short (Dark, et al., 2008).

The use of current event case studies provided students with many realistic situations and students can begin to understand the "shades of gray" of an ethical quandary. Some ethical dilemmas involve principles, while others are related to consequences, and still others correspond to virtues (Quinn, 2006). Case-based analysis allows students to think creatively imagining the features that would make a decision or action unambiguously right or wrong. Some of the decisions may be based on utilitarian principles, duties, rights, or virtues (Quinn, 2006).

The use of ethical current events improved student engagement and increased student interest, motivation and participation in discussions. Additional benefits of including the current event component are:

- "The content of the course assignments remains fresh.
- The risk of student generated "paper files" that are recycled every semester are reduced thereby cheating is also reduced.
- Course material of ethical considerations is relevant and directly applicable to current events with consequences affecting real people, and real companies.
- Examples are realistic and a naturally occurring case study, with all of its real world messiness is on display.

- Content is broader and more diverse and can include an international perspective" (Hare, 2008).

The technology will keep evolving and advancing at an ever-increasing pace. "Our reliance on networks and interconnected systems pose new threats and present new challenges, requiring us to find new ways of working" (Landau, 2008).

Cyber ethics must be taught with a pedagogical approach that allows students to examine their personal ethical beliefs, in the broader explicit context of right and wrong. (Dark, et al., 2008). The course content must address the ever-changing environment of existing technical, professional, legal and cultural values.

Instead of being black or white, global values, especially those of business and technology, are invariably tainted in complex shades of gray. Computer Ethics is arguably, the only field of study in which CIS and IT students are compelled to formulate and defend their own opinions on public issues. "Software developers in particular potentially wield immense virtual power and should be mindful of their artifacts' long-term consequences and their works' social context" (Lenarcic, 2003).

"If computer experts don't act in a manner that garners and maintains public trust, then the field and its potential to create enormous benefit will not be fully realized. Progress will be slowed and diverted as outside regulations jump in and the public has mixed experience" (Johnson, 2008).

In conclusion "With great power comes great responsibility." (Roosevelt, F., D., Zevin, B. D, 1946).

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Appendices

Appendix I – Professional Organizations Code of Ethics

ICCP Code	ACM Code	AITP Code
ICCP Prin. 1: The IT professional will embrace a high standard of skill and knowledge	ACM Prin. 1: ACM members should act with integrity	AITP Prin. 1: AITP members should promote management's understanding of information processing methods and procedures
ICCP Prin. 2: The IT professional will maintain a confidential relationship with people served	ACM Prin. 2: ACM members should strive to increase their competence and the competence and prestige of the profession	AITP Prin. 2: AITP members should uphold the high ideals of the AITP, cooperate with each other and treat each other with honesty and respect
ICCP Prin. 3: The IT professional will recognize public reliance upon the standards of conduct and established practice	ACM Prin. 3: ACM members should accept only those assignments for which there is reasonable expectation of achieving the requirements or specification of the project and perform his assignments in a professional manner	AITP Prin. 3: AITP members should participate to the best of their abilities in the dissemination of knowledge pertaining to the general development and understanding of information processing and should not use knowledge of a confidential nature to further their own interests. AITP members should not violate private or confidential information entrusted to them or that they may gain access to
ICCP Prin. 4: The IT professional will observe an ethical code	ACM Prin. 4: ACM members should act with professional responsibility	AITP Prin. 4: AITP members should uphold the educational institution's ethical and moral principles
	ACM Prin. 5: ACM members should use specialized knowledge and skills for the advancement of human welfare	AITP Prin. 5: AITP members owe trust to their employers to guard the employers' interests and to advise the employers wisely and honestly
		AITP Prin. 5: AITP members should respect their countries and the chosen way of life of those countries and act accordingly

Appendix II – Grading Rubric for Cyber Ethics Report

GRADING RUBRIC				
	D	C	B	A
POINT SCORE:	10	15	20	25
Criteria	**Non-performance**	**Basic**	**Proficient**	**Distinguished**
Students identify ethically relevant facts that together provide a comprehensive summary of the ethical issues raised in the literature.	Leaves out facts that are ethically relevant. Organization and List of Ethical Issues is Not Easily Identified.	Includes facts that are ethically irrelevant or only marginally relevant. Organization and List of Ethical Issues Needs Improvement.	Includes most of the ethically relevant facts. Organization and List of Ethical Issues is easily understood and refined.	Creates an excellent assignment demonstrating high competency. All ethical issues are clearly identified.
Students identify the stakeholders and their different viewpoints. They justify their claims using ethical arguments as well as isolate potential stakeholder conflicts.	Stakeholders viewpoints left out, justification of claims and potential conflicts are poorly made. Possible Conflicts not identified.	Only Some stakeholder's viewpoints mentioned, justification of claims and potential conflicts are partially made. Possible Conflicts are partially included.	Almost all stakeholders are included , explained, and justified. Almost all stakes and potential conflicts are included, explained, and justified.	All stakeholders are included , explained, and justified. All stakes and potential conflicts are included, explained, and justified.
Student correctly uses problem categories (**disagreement, & conflict**) to classify the ethical components. The ability to uncover the ethical issues that are embedded in complex, concrete situations.	Identification of problem types employed incorrectly, incompletely, or in a confused way. Problem classification is not relevant.	Problem classification is not directly relevant to the case and misses significant ethical elements in the case	Problem classification is, for the most part, relevant to the case. Problem classification covers most of the significant ethical elements in the case	Problem classification is highly relevant to the case and insightful. Problem classification covers comprehensively the ethical elements in the case.
Creates document that is clearly written and generally free of grammatical errors.	Does not have good format and does not create a document that is clearly written and generally free of grammatical errors.	Follows the format guidelines or creates document that is clearly written and partially free of grammatical errors.	Follows format guidelines and creates document that is clearly written and generally free of grammatical errors.	Follows format guidelines and creates document that is clearly written, well organized, and completely free of grammatical errors.

Appendix III - Web Resources

Other relevant web sites that have information on the social implications of computer use including computer crime, ethics, security measures, privacy, employee monitoring, and relevant topics are as follows (Haag, 2007):

General

www.eos.ncsu.edu/eos/info/computer_ethics - a good site for information on various issues of proper and improper use of computer resources.

www.cpsr.org/ - the Web site of Computer Professions for Social Responsibility contains links to information on various aspects of computer usage.

Ethics and Computer Crime

www.acm.org/constitution/code.html – the Association for Computing Machinery's (ACM) code of ethics.

www.techtv.com/cybercrime – the companion Web site of the TV cable network with information on computer crime, legislation, privacy issues, and so on.

www.consumer.gov/sentinel – Federal Trade Commission site that has statistics on complaints from Web users.

Legislation

www.complaw.com – a law library that provides information on laws in existence and proposed on privacy, monitoring, etc.

aspe.hhs.gov/admnsimp/final/pvfact2.htm – Health and Human Services department fact sheet on the new federal law protecting patient's health information.

Privacy

www.privacyfoundation.org - site has detailed information on privacy issues.

www.eff.org – the Electronic Frontier Foundation offers some helpful guidelines on privacy and discusses some questionable marketing tactics.

epic.org – the Electronic Privacy Information Center has information on privacy and links to all sorts of privacy tools that you can use to protect yourself.

Defensive Tools

www.grc.com – the Gibson Research Corporation Web site has software that can test your computer's vulnerability to outside intrusion.

www.opt-out.cdt.org – the Center for Democracy and Technology has information on tracking services and links to opt-out pages for many Web sites.

www.fbi.gov – the Federal Bureau of Investigation's (FBI) Web site where you can file a complaint.

www.ftc.gov - the Federal Trade Commission's (FTC) Web site has lots of information on how to protect yourself on the Internet and how to file complaints.

www.nasaa.org – the North American Securities Administrators Association site with links to sites in all 50 states that track investment fraud.

www.website101.com/Privacy_issues.html – Small Business Privacy Tutorial on SpamFilter

Computer Ethics on World Wide Web: http://www.ethicsweb.ca/resources/computer/index.html
Computer Ethics Institute: http://www.brookings.edu/its/cei/cei_hp.html
Writting and Analyzing Ethics Cases: http://cnx.org/content/m15991/latest/

Appendix IV – Sample References for Cyber Ethics Report

T. J. Max Credit Card Breach
TJMAX1.doc (30.5 Kb)

Second Article On T J Max Credit Card Breach
TJMAX1.doc (30.5 Kb)

Wal-Mart Customer Data
walmart-customer data.pdf (128.541 Kb)

Iron Mountain Missing Data
IronMountain-Missing-Data.pdf (22.948 Kb)

FBI Carnivore Internet Surveillance
FBI-Carnivore-Update.pdf (21.359 Kb)

Power Grid Security
power grid security.pdf (58.895 Kb)

E-Commerce Trust
e-commercetrust.pdf (709.856 Kb)

Chinese Censorship
Chinese-Censorship-Microsoft.pdf (56.456 Kb)

Spyware Phishing Overview
SpyWare-Phishing-Overview-PRINT.pdf (74.013 Kb)

Visa Credit Card Operations
Visa Credit Card Operations.pdf (212.291 Kb)

E- Commerce Security
E-CommerceSecurity.ppt (2.374 Mb)

Gartner E-Commerce Trust
gartner.docx (14.992 Kb)

IBM Copyright infringement
IBMcopyright.doc (28 Kb)

Megan Meier Cyber Stalking
Cyber StalkingMeganMeier.doc (29 Kb)

Cyber Security
cybersecurity.pdf (98.286 Kb)

Email Phishing Example
Emailphisingexample.ppt (478 Kb)

Data Protection
DataProtection.pdf (512.936 Kb)

Washington Post Article on Cyber Attacks
http://www.washingtonpost.com/wp-dyn/content/article/2010/02/17/AR2010021705816_pf.html

Appendix V –Cyber Ethics Report Topics

Identity Theft

- Benefits and Risks of E-commerce and Internet Shopping
- Internet Scams / False Charity Sites
- Electronic Data storage of Birth, Marriage, Death Certificates
- Recommendations to Prevent Identity Theft
- Case Examples of Who, When, What Happened
- Laws Against Identity Theft
- Statistics – How Frequent is Identity Theft, Who are the Victims, Victim Profiles
- Size of the Problem, Volume of Crimes, Monetary Value of Crime
- Criminal Prosecuted and Sentenced
- What is legally being done by government?

Internet Crimes/Computer Security

- Viruses/SPAM
- Spyware
- Phishing
- Hacking
- Security of Government Computers and Records
- LDAP Security Risks
- Trojan Horses
- Deep Packet Inspection of Email and Internet Usage
- Bandwidth Throttling
- What are Laws Against It
- What is being done legally by government
- Statistics - How Frequent, Who are the Victims, Size of Problem, Volume of Crimes
- Criminals Prosecuted, Sentenced
- Recommendations to Prevent It
- Government Security Regulations regarding computer usage for Department of Defense

Cyber Bullying/ Cyber Stalking

- Megan Meier Case
- Social Networking Sites
- Internet Dating Sites
- Parental Responsibilities
- Laws Against It
- Prosecution of Mrs. Drew
- Recommendations to Prevent It
- Should Laws Be Changed?
- What security should be on social networking sites

Wireless Hacking

- Recommendations to Prevent It
- Case Example - Who , When, What Happened
- What are Laws Against It
- Statistics - How Frequent, Who are the Victims, Size of Problem, Volume of Crimes

Internet Bandwidth Throttling

- What are the consequences to consumers?
- What are the justifications made by ISPs?

- What are the new laws regarding this?
- Recommendations about what should be done in the future?

RFID Tags
- Consumer Privacy
- Passports
- Inventory Management: Company Policies, Improved Inventory Management, Efficiency Cost Savings

Employee Monitoring
- Computer Usage
- Email Monitoring
- Video Surveillance
- Employer: Productivity, Loss of Information, Provide Safe and Secure Work Environment
- Employee: Invasion of Privacy, Stress, Loss of Motivation
- Case Example - Who , When, What Happened
- Laws Against It
- Recent Court Cases

Search Engine Privacy
- Google/Yahoo/Microsoft
- Google subpoenas Consumer Public Views
- Case Example - Who , When, What Happened
- What are Laws regarding this?
- Record retention periods
- Why do companies do this?
- Recent Court Cases for death of wife

Chinese Government Censorship of Google/Microsoft
- What are positions of Google and Microsoft companies?
- What are positions of Chinese government?
- Is this in conflict with American Standards?
- What is public opinion in America?
- Pros/Cons of censorship

Customer Relationship Management
- Walmart Customer Purchasing History usage of RFID for Inventory
- Usage of Point of Sale Transactions for Data Warehousing and Analytics
- TJ Maxx Security Breach
- Consumer Privacy , Corporate Profitability Inventory Efficiency etc.

Homeland Security/Airport Security
- Full Body Scanners
- Government monitoring of email/phone calls
- Passenger Profiling
- Power Grid Security
- National Security
- Invasion of Privacy/Discrimination
- Health Issues of scanners
- What are the laws?
- Case Example of Government Invasion of Privacy
- Airport & Airline Concerns

Internet Music/Intellectual Property

- Case Examples
- RIAA vs. Verizon - Digital Millennium Copyright Act DMCA
- Private Bay - Peer to Peer Sharing Swedish Case
- Music Company Point of View
- Consumers Point of View
- Creative Commons and "Jay-z / Beatles Gray Album"
- Napster History

HIPPA Records Electronic Medical Records

- Medical Identity Theft
- Falsified Billing Records by Doctors
- Consumer Privacy
- Company Policy - Improved Accuracy, Efficiency, Cost Savings
- Case Example - Who , When, What Happened
- What are Laws?

Software Piracy

- IBM vs. BGC - Informix Data Base Licenses
- Lost Revenue Facts
- Poorer Economies in Under-developed countries cannot afford full software prices.

Exploring the Connection between Age and Strategies for Learning New Technology Related Tasks

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Abstract

This paper discusses the connection between age and strategies for learning new technology related tasks. Many users have to learn about new devices and applications on a frequent basis and use a variety of strategies to accomplish this learning process. Approaches to learning new technology related tasks vary and can contribute to a user's success or failure in mastering these tasks. Little research exists on how this affects older users actively pursuing education. This study focuses on how learning strategies, types of errors, and attitude can vary among users of different age groups. A survey was administered to two user groups, one was a group of traditional age students taking introductory general education courses at a Mid-Atlantic comprehensive university, the other was a group of members of the Osher Lifelong Learning Institute at the same university. The results of this study highlight the importance of considering age related changes in learning styles, types of error, and attitude when introducing new technology related tasks. The paper concludes with a summary of considerations for content delivery and plans for future research.

Keywords: learning strategies, new technology tasks, age

1. INTRODUCTION

Technology is integrated into many daily tasks, such as driving cars with global positioning systems, communicating with cell phones, or using the Internet for research, online banking, or education. In the current environment of fast evolving technologies, users are often in situations where they need to learn new tasks related to technology. Examples of such technology related tasks include learning to use newer versions of well-known devices (such as smart phones) or learning how to use newer applications (such as social networking applications) in a relatively familiar environment such as the internet. Approaches taken to learn such technologies vary, and can contribute to success or failure. Research has been investigating how individuals approach innovative technology, and what types of strategies individuals employ when learning new technologies or new tasks related to technology (Rogers, 1995; Dunlosky and Connor, 1997; Czaja and Lee, 2008). While there has been considerable research examining adoption of innovative and new technologies, an area that is perhaps less well understood is how an individual's attitude, types of error, and approach towards learning new technologies

change with age. Gaining insight about age related factors influencing learning strategies is becoming even more critical with the growing number of older adults actively seeking education and training (Lakin, Mullane et al., 2007).

2. BACKGROUND

Computer use by seniors is steadily increasing; more seniors are now online than in the past and outpace younger users when it comes to online health information, government websites and religious information (Fox and Jones, 2009). More adults age 50 and over than ever are enrolling in higher education, and higher education institutions are working on identifying how program delivery can be adapted to serve this increasing population (Lakin, Mullane et al., 2008). Older users primarily seek higher education for intellectual stimulation, sociability, and skills enhancement; to serve the needs of this population, higher education programs should evaluate current learning formats and possibly create new learning formats considering senior preferences (Lakin, Mullane et al., 2008).

Unfortunately, many older users find that technology products are not easy to use, and often experience problems, especially when using complex software. This user group often uses less efficient search strategies when using the internet, encounters more errors than younger users, and also has more difficulty recovering from these errors (O'Connell, 2007; Czaja and Lee, 2008). However, with training and support, older users could successfully complete their tasks and have a positive user experience (Czaja and Lee, 2008).

Research shows that training results are influenced by how older users learn and also that younger and older users differ in their approach to problem solving (Mead and Fisk, 1998; Chadwick-Dias, Tedesco et al., 2004; Fairweather, 2008). For example, ATM training for older users has been especially successful when an active, hands-on approach was used. Comparing conceptual training (declarative principal) with action training (hands-on), action training has shown to be superior for training older adults. Older adults retained more and better when a practical, hands-on, purpose driven approach was used. Although both younger users and older users retain performance better on procedural tasks than on episodic memory tasks, the procedural advantage was larger for the older adults than for the younger adults (Mead and Fisk, 1998).

In addition, task performance is influenced by cognitive, perceptual, and motor abilities, which decline with age. This may affect many tasks, including analysis of complex processes, perceiving and comprehending visual information, or basic pointing and selecting tasks when interacting with computer applications (Chadwick-Dias, Tedesco et al., 2004; Czaja and Lee, 2008). Task performance in older adults is also affected by changes in information processing speed and working memory (Rogers, Hertzog et al., 2000). Moreover, aging is an individualized process, and although certain trends and preferences have been observed, abilities and experiences can vary considerably among this user group (Czaja and Lee, 2008).

In comparison, younger technology users are often called the net-generation due to the fact that they are introduced to technology at a very early age. Younger users are often active in communication technology such as social networking, and especially like working in a collaborative environment. Almost all teens (97%) between the age of 12-17 play in online games, and over half participate in social networking (Fox and Jones, 2009). This preference for collaborative environments has implications for student learning: wikis, blogs, twitter, or second life have been successfully integrated into many learning environments and offer students options for knowledge construction and knowledge building in a collaborative context (Bruckman, Bandlow et al., 2008; Pusey and Meiselwitz, 2009).

The following work investigates the connection between age and learning strategies for learning new technology related tasks considering elements of educational learning theory and human-computer interaction. The aim of this study is to identify possible user preferences and trends which could assist in developing and supporting learning environments for senior users pursuing continuing education.

Educational Theory

Learning environments have undergone a change in the 20th century and moved from a more structured, outcome focused approach to a less structured, open-ended focused approach. Within the large body of educational theory, the two cornerstones of this movement can probably

best be described with the principles of behaviorism and constructivism. Behaviorism represents the structured approach; constructivism represents the open-ended approach, with many variations in between. Behaviorist theory defines learning as an individual's response to events and is very outcome oriented – the expectation being that behavior resulting in desired outcomes is likely to be repeated (Skinner, 2009). Behaviorist models of learning are often applied where knowledge can be separated into smaller chunks of material that is related to certain skills, for example in computer-based instruction dealing with well defined areas of skill development or in clinical applications, for example for children with autism (Jonasson, 2001; Charlop-Christy, Carpenter et al., 2002).

Constructivist learning environments focus on knowledge building in context and collaboration, and promote higher order thinking skills. Social context becomes increasingly important in the meaning making process where learners construct their own knowledge and use a process of social negotiation to share multiple perspectives of reality (Jonasson, 2001). Learners are highly involved in the learning process and often shape their own learning experience (Land and Hannafin, 2000; Jonasson, 2001). Learning environments today cover a wide range of models ranging from behaviorism to constructivism. Student-centered learning, applied learning, problem-based learning, microworlds, or situated cognition are only a few examples describing learning environments emphasizing varying degrees on the scale between strict behaviorist and strict constructivist learning environments (Land and Hannafin, 2000).

Human-Computer Interaction

The human-computer interaction literature identifies different approaches to training computer users on how to learn a new application. Most of these research studies focus on how to improve user task performance, primarily on office automation applications such as word processing, spreadsheet software, and database software, or web browsing (Lazar and Norcio, 2003).

These different approaches include exploratory training, procedural training, error management training, and conceptual models (Dormann and Frese, 1994; Nordstrom, Wendland et al., 1998) . In procedural training, users are told the specific actions and steps to take, and are encouraged to repeat those actions. In exploratory training, users are not told exactly what to do. Rather, they are given information about the overall environment, and are encouraged to learn by exploring. Error management training assumes that errors will occur, and that users need to be prepared for dealing with errors. Error management training involves teaching people strategies for responding to errors, and also provides users with positive reinforcement about errors (e.g. "you can learn from your error" and "great! You have made an error!"). Conceptual models are graphical representations of systems, to explain how they operate (Sein, Bostrom et al., 1987; Sein and Bostrom, 1989). Minimalist documentation and training are approaches to present only basic information to the user (Carroll, 1984). Similarly, a classic article on the HCI literature talks about the "training wheels interface" where all of the advanced features are turned off, providing a limited experience, but also a limited chance of making an error (Carroll and Carrithers, 1984). It is well-documented in the HCI literature that different user populations have different interface-related needs (Shneiderman, 2000). For instance, older users have different interface needs from young users, such as requiring larger clickable icons and fonts (Mead, Spaulding et al., 1997; O'Connell, 2007). Older users also tend to have more problems confronting and dealing with errors (Birdi and Zapf, 1997), and find it challenging to deal with multiple application windows and scrolling text (National Institute on Aging, 2002).

It seems that there is likely a connection between the procedural concept used in the HCI literature, and behaviorism in the education literature. Similarly, there is likely a connection between exploratory approaches in the HCI literature, and constructivism from the education literature. Training in the HCI literature is often focused on the novice user, someone who is new to computing, or new to a new category of applications, but as the HCI community has focused less on training, that definition may have become outdated. Very few individuals could now be considered "new to computing" in the industrialized world, rather, "new to a task" might be a better term. The focus of this study is not on people who have never used a computer, but rather on users who have to learn new tasks associated with a new type of device, or a new category of software application.

3. METHODOLOGY

It was the purpose of this research to investigate the following relationships: a) between age and learning strategies when learning a new technology related task, b) between age and types of problems encountered when learning a new technology related task, and c) between age and attitude towards learning a new technology related task. In addition, relationships regarding the employment situation were also evaluated, as well as differences related to gender. Two groups participated in this study. One group of participants consisted of 46 students enrolled in several general education courses at a medium-sized comprehensive university in the Mid-Atlantic. All courses were introductory course, were open to all students, and did not require any prerequisites. The second group of participants consisted of 95 members of the Osher Lifelong Learning Institute affiliated with the same medium-sized comprehensive university in the Mid-Atlantic. The Osher Lifelong Learning Institute offers adults age 50 and older opportunities for continued learning, along with programs and activities for social and cultural enrichment.

A survey was administered at the end of the Spring 2010 semester to both groups. The survey consisted of a total of 12 questions (with subcategories). Included were questions collecting demographic data, questions addressing procedural/behaviorist and exploratory/constructivist learning strategies, questions related to the types of errors user encounter, and questions inquiring about user attitudes when learning a new technology related task. The survey was administered online and was purposely brief (after some initial consultations with the administration of the Osher Institute), to encourage participation and limit possible challenges of the online environment. The survey also included room for open ended comments.

4. RESULTS

The following section reports the results of the study, including the description of the respondents, learning approaches, most likely problems encountered, and attitudes when learning a new task related to technology.

Description of Respondents

The sample for the younger age group was taken from several introductory computer science courses. In this group, a total of 46 students responded, and more than half of the students were female (69.6%). The majority of students were in the traditional full-time college student age range; 52.2% were 20 years or younger, 43.3% were between 21-30 years, and only 4.3% were older than 31 years. Of this group 63% were working, and 77.4% of those students employed were working up to 20 hours per week.

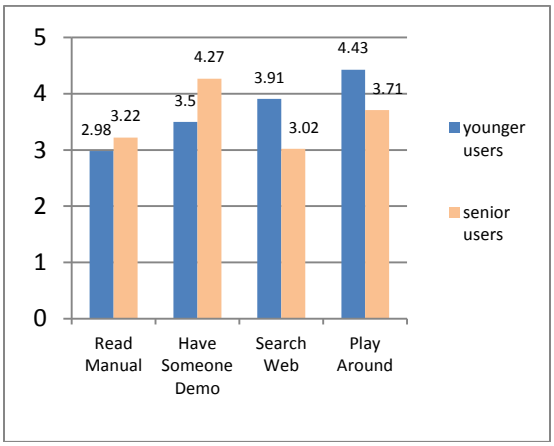
The sample for the senior age group was taken from members of the Osher Lifelong Learning Institute affiliated with the university. A total of 95 members responded, 72.6% were female. The majority of respondents (78.9%) were 66 years or older (21.1% were between 66-70 years old, 33.7% were between 71-75 years old, and 24.2% were 76 years or older). The number of working/non-working members was almost evenly divided, 49.5% were working, and of those respondents 77.6% were working up to 20 hours per week.

Considering hardware, the majority of seniors were using traditional desktops, whereas the younger user group used more laptops and smart phones. In the application areas, both groups used email and web browsing/searching often, but the younger age group used social networking sites often (daily), whereas the senior age group used this type of application rarely (once a week or less).

Procedural/Behaviorist vs. Exploratory/Constructivist Approach

Several questions addressed the learning approach when users are faced with learning new tasks related to technology. The questions addressed a range of approaches, including mainly procedural/behaviorist approaches such as reading a manual, moderately procedural/behaviorist approaches such as watching a person demonstrate the topic, moderately exploratory/constructivist approaches such as searching the web for information, and mainly exploratory/constructivist approaches such as playing around with the device or software to figure it out. Users responded on a 5-point scale (1=strongly disagree, 5=strongly agree), indicating how much they favored each approach. Table 1 presents the results of younger and senior users rating their preference.

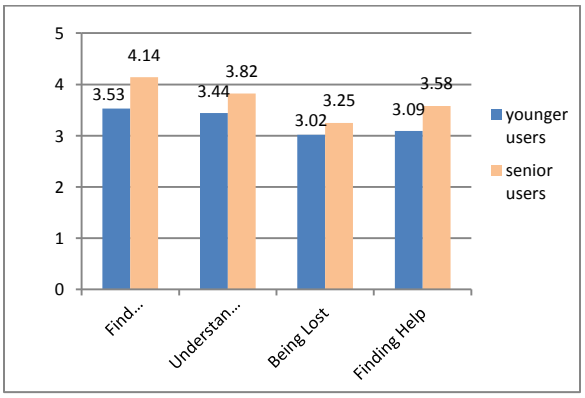
Table 1. Procedural/behaviorist vs. exploratory/constructivist approach preference



Results show that younger users clearly prefer the mostly exploratory/constructivist approach. When mastering a new technology related task, they would rather search the web for information or play around with new equipment or applications until they can figure out how to use the new device or software. Younger users least liked the mostly procedural/behaviorist approach of reading the manual (M=2.98, SD=1.13). Senior users preferred the moderately procedural approach of watching someone demonstrate the task (M=4.27, SD=0.98), and they least preferred the moderately exploratory approach of searching the web for information (mean=3.02, SD=1.42).

Common problems when learning a new technology related task

Table 2. Most likely problems



The survey results demonstrate that most users in the younger as well as in the senior age group are experiencing similar problems. Users responded on a 5-point scale (1=strongly disagree, 5=strongly agree) indicating the magnitude of the issue. Table 2 below presents the most likely problem users encounter when they set out to learn a new technology related task.

Surprisingly, the order of most common problems is identical for younger and senior users; the most common issue for both age groups is finding a particular functionality. Although seniors (M=4.14, SD=0.99) rate this problem as slightly more significant than younger users (M=3.53, SD=0.96), locating a particular functionality is the number one problem for all surveyed users. The number two issue for younger as well as senior users is the clarity of error messages; both user groups rate the problem of understanding error messages as the second largest obstacle when mastering new technology related tasks. Finding help is ranked third, and being generally lost is ranked fourth in the order of common problems.

Attitudes when learning a new technology related task

Users responded on a 5-point scale (1=strongly disagree, 5=strongly agree) indicating the degree of the attitude. Younger users generally had a more positive viewpoint when learning new tasks related to technology. Table 3 summarizes user attitudes towards learning these tasks.

Table 3. Attitudes

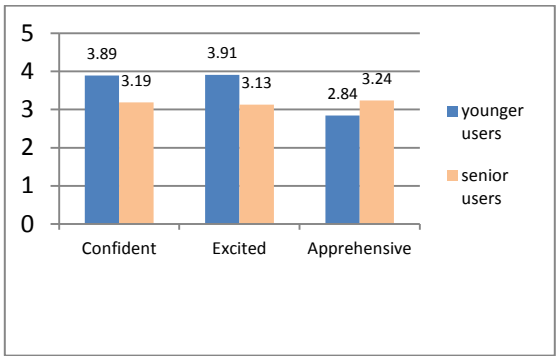


Table 3 displays that the majority of younger users show positive attitudes. Younger users reported high confidence (M=3.89, SD=0.93) and excitement (M=3.91, SD=0.86), whereas the highest ranked attitude within the senior user group is apprehension (mean=3.24,

SD=1.37). However, rankings for the senior user group are very close, with apprehension only slightly higher rated than confidence.

Correlation between Age and Learning Strategy Approach, Common Problems, and Attitudes

This section reports results pertaining to the research question: Is there a significant relationship ($p<0.05$) between age and learning strategy approach, age and common problems, and age and attitude when learning a new technology related task? A positive relationship between age and any of the factors would demonstrate that when the age increases, the other factor also increases. A negative relationship between age and any of the factors would demonstrate that when the age increases, the other factor decreases. Table 4 presents an overview of the significant correlations using Pearson's correlation.

Table 4. Pearson Correlations

		Age	Demo	Search Web	Play Around with It	Excited
Age	Pearson Corr.	1	.316(**)	-.313(**)	-.326(**)	-.312(**)
	Sig. (2-tailed)	.	0	0	0	0
	N	141	138	134	137	132

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

Analysis of the relationships (using Pearson correlation) indicates that some moderate relationships exist. A moderate positive relationship exists between age and the moderately procedural/behaviorist approach of having someone demonstrate the new task. This seems to imply an increased preference for moderately procedural/behaviorist approaches with increased age. Further, three moderate negative relationships are reported. A moderate negative relationship between age and the moderately exploratory/constructivist learning approach of searching the web demonstrates that as age increases, the preference for moderately exploratory/constructivist learning approaches decreases. Another moderate negative relationship between age and the mainly exploratory/constructivist learning approach of playing around to figure out the new task also demonstrates that as age increases, the preference for mainly exploratory learning approaches decreases. Lastly, a moderate negative relationship between age and excitement showed that as age increases, excitement about learning new tasks related to technology decreases. There were no significant relationships reported between age and common problems encountered when learning a new technology related task.

Gender

Learning preferences by gender were evaluated using ANOVA. Results showed a significant difference among gender and moderately procedural/behaviorist learning strategies ($F_{(1,135)} = 30.75$, $p<0.0005$). Overall, in all users, a significant difference was identified for learning approaches among gender. A moderately procedural/behaviorist approach was clearly preferred by female participants, and this was confirmed overall as well as for the separate age groups of younger users ($F_{(1,45)} = 34.52$, $p<0.0005$) and senior users ($F_{(1,89)} = 8.07$, $p<0.05$).

5. DISCUSSION

In this study we report the results of an exploratory study investigating the relationship of age with learning strategies, problems faced, and attitudes in the context of learning involving new technologies. The results of this study show that user preferences for learning strategies when learning a new technology related task may differ depending on the age of the user. The study indicates a moderate correlation between age and preference of procedural and exploratory learning. Results show that as age increases, the preference for moderate procedural/behaviorist learning strategies increases and the preference for mainly exploratory/constructivist learning strategies decreases. Senior computer users in this study prefer a moderate procedural approach with the option for interaction. This finding is also supported by many comments to open ended questions, where senior users described their good experience with demonstrations and tutorials. However, it should be noted that they preferred to have person-to-person contact; senior users clearly preferred someone demonstrating a feature or device over watching online tutorials. Younger users preferred the largely exploratory/constructivist approach and least favored the largely procedural/behaviorist approach. In addition,

the level of excitement about learning new tasks related to technology declined with age.

Another item, the number of hours per week individuals were working, did not show any correlation to learning strategies, types of error encountered, or attitudes. Also, the number of hours per week individuals used their computer for work or for fun/play did not show any correlation to learning strategies, types of error encountered, or attitudes.

Gender in both younger and senior users revealed similarities regarding learning approaches. Overall, a moderately procedural/behaviorist approach was preferred by female participants.

Interestingly, the study showed that ranking of the most common problems was identical for younger as well as senior users; suggesting that users learning new technology related tasks are faced with the same problems, but use different strategies to overcome these problems.

It should be noted that most of the participants were traditional age students and participants 50 years and older, the survey had few participants in the age group between 35-50 years. Further, all participants in the senior user group were a members of the Osher Lifelong Learning Institute at the university.

This study was a pilot study for a larger study to follow, and due to the brevity of the survey, results were limited. Future research intends to expand the survey and the age groups of participants. A larger study to follow is planned with an increased participation in the middle age group (35-50 years) as well as a more disaggregated scale of learning approaches, and possibly integrating the VARK approach (visual, auditory, reading, and kinetic preferences). Further research will also investigate the integration of face-to-face contact between instructor and learner as well as between learner and learner. For example, learning approaches supported by tutorials and demonstrations involving face-to-face support in several forms, such as tutorials with personalized, live chats, or introductory movies including a question and answer session could be possible options.

Evaluating learning strategies in relation to age has the potential to increase functionality and usability of new devices and software. Learning strategies could be supported by interfaces and help features to make learning new technology related tasks more efficient, especially for seniors. This in turn could shorten training and/or learning time and lead to a more efficient process when mastering new technology related tasks.

Moreover, results showed some gender preferences across age groups, and also pointed out that younger and older users agree on the most common problems; increased instructor awareness about user learning strategies when learning new technology related tasks could improve the learning process for both, younger and senior users.

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Selecting a Good Conference Location Based on Participants' Interests

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Abstract

Selecting a good conference location within budget constraints to attract paper authors and participants is a very difficult job for the conference organizers. A conference location is also very important along with other issues such as ranking of the conference. Selecting a bad conference location may reduce the number of paper submissions and create bad impressions on the conference to the paper authors and conference participants. The conference location should be selected in such a way that it can attract authors to submit papers as well as others to participate/attend. In this paper we discuss how to select a good conference location within budget constraints that can attract many authors/participants considering participants' interests. We propose several methods to select the best location among the available possible locations within budget constraints based on the authors and participants interests on various features or attributes of the locations. Our problem also has interesting applications in information systems education as well. We perform evaluation of our proposed algorithms both on real and synthetic data.

Keywords: selecting conference location, budget constraints, authors and participants interests.

1. INTRODUCTION

Selecting a good location is one of the key issues in success of a conference in addition to other important aspects such as budget/cost. It is not an easy job to select a perfect location for a conference to attract and satisfy conference participants; and even harder within budget constraints. The chance of success of a conference depends in a major way upon the choice of the conference location. The location has to be selected with extreme care, in order to organize the conference successfully. As one of the most important ingredients to a successful conference, choosing the right location is a task that cannot be taken lightly.

People tend to pick places such as hotels, resorts, and conference halls to hold conferences. Numerous factors such as the time span of the conference, the number of attendants, overall environment, ambiance of the location, technology available, surrounding activities and places, travelling, transportation, accommodations, etc. have to be taken under consideration when choosing a location.

Among the possible locations, the organizers need to select the best one that can satisfy the participants (e.g., paper authors and other attendants) in terms of the facilities available in the location as well as other factors mentioned above. We will mention participants throughout the paper which represents paper authors, workshop organizers, tutorial providers, and all other attendants.

Participants tend to prefer conference location based on certain factors such as time of the year, duration of the conference, minimum travel, comfortable accommodation, expense, interesting activities and places to visit available around, and so on. Participants prefer a conference location just not for participating and listening to the presentation, but also to visit some interesting places nearby and performing

other activities as well possibly with accompanying family members, friends, colleagues, and other conference attendants. So the participants can express their interests based on the available features specific to possible locations and the organizers can choose the best location that can satisfy as many participants as possible.

Consider a conference organizer wishes to select a location from the available set of possible locations, given the feature preferences of its potential participants. For example, a conference location *A* has the following elements: *close to the beach*, *WiFi available*, *restaurant on site*, *swimming pool*, and *accommodation in the same building*. Another location *B* has the following elements: *close to the mountain*, *no WiFi available*, *free local transportation*, and *accommodation may or may not be in the same building*. The potential participants can express their interests by specifying "yes" or "no" for each element – where "yes" means interested on the element and "no" means not interested or do not care. The purpose of conference organizer is to select the location *A* or *B* based on these elements to satisfy as many participants as possible. The conference organizer can collect the preferences in terms of survey based on the possible features from the participants (previous paper authors and attendants) to select the location in future. Because of the vast use of internet now-a-days, it is very easy to collect such preferences online through online surveys, search queries, on-site surveys during conference, and other ways.

The problem also has interesting applications in information systems education such as designing an information systems course that can attract students and meets industry demands, designing a program to meet constantly changing technological world to produce better graduates, and so on.

We summarize our major contributions next.

Major Contributions:

1. We define the problem of selecting best conference location among the available possible locations within budget constraints based on participants' interests.
2. We present several algorithms based on different semantics.
3. We perform evaluation of our proposed algorithms both on real and synthetic data.

The rest of the paper is organized as follows. Section 2 provides formal problem definitions. Section 3 discusses details of the proposed algorithms. In Section 4 we present the result of extensive experiments, and discuss other interesting variants in Section 5. We discuss related work in Section 6 and conclude in Section 7.

2. PROBLEM FRAMEWORK

In this section we formally define the main problem for Boolean data. As we discuss in Section 5, many other variants can be reduced to this problem. First we provide some useful definitions.

Available Locations Database: Let $D = \{t_1 \ldots t_N\}$ be a collection of Boolean tuples over the attribute set $A = \{a_1 \ldots a_M\}$, where each tuple t is a bit-vector where a 0 implies the absence of a feature and a 1 implies the presence of a feature. A tuple t may also be considered as a subset of A, where an attribute belongs to t if its value in the bit-vector is 1. Each tuple t in database D represents an available possible conference location.

Survey Log: Let $Q = \{q_1 \ldots q_S\}$ be collection of survey results where each tuple q defines a subset of attributes which represents survey result from a respondent (participant).

The problem definition is as follows:

Conference Location Selection (CLS) Problem: *Given an available locations database D, and a survey log Q, select a tuple t from D such that the number of tuples in Q satisfied by t is maximized.*

The following running example will be used throughout the paper to illustrate various concepts.

EXAMPLE 1: *Consider a database of possible available conference locations, which contains a single database table D with N rows and M attributes where each tuple represents a possible location. The table has numerous attributes that describe details of the location: Boolean attributes such as On the Beach, WiFi Available, On-site Accommodation, Close to Major International Airport, Close to National Park, National Museum in the Area, etc; numeric attributes such as Distance from the Airport, Number of Accommodations available, etc; and text attributes such as Reviews, and so on. Figure 1 illustrates such a database (where only the Boolean attributes are shown) of four*

locations available within the budget constraints. The figure also illustrates a survey log of five tuples collected from five respondents or participants. Now the job is to select a tuple t from database D that can satisfy as many tuples from survey log Q as possible □

Location	*Beach*	*Wi Fi*	*Accommodation*	*Intl. Airport*
t_1	1	0	1	0
t_2	0	1	0	1
t_3	0	1	1	1
t_4	1	0	1	1

Available Locations Database *D*

Tuple ID	*Beach*	*WiFi*	*Accommodation*	*Intl. Airport*
q_1	1	1	0	1
q_2	0	1	1	0
q_3	1	1	1	0
q_4	0	1	1	1
q_5	1	0	0	1

Survey Log *Q*

Figure 1. Illustrating EXAMPLE 1

3. PROPOSED ALGORITHMS

In this section we discuss our main algorithmic results. We propose four algorithms and discuss them next in detail.

Algorithm based on Maximized Features Coverage (*MFC*)

The intuition of this algorithm is that we look for a tuple in the database of available possible locations that has maximum sum of scores over all tuples in the survey log. That means, find a tuple *t* in *D* such that it satisfies as many of the conditions or features asked by the tuples in *Q* as possible. It is a best-effort problem and hence the algorithm is polynomial time algorithm. We assume that the scoring function is an aggregation of the scores of the individual attributes/features, e.g., the sum of the attribute contributions. The attribute contribution could be 1 if it is satisfied or 0 otherwise. For a text database, it could be the tf-idf weight of a keyword. The tf–idf weight (term frequency–inverse document frequency) is a statistical measure used to evaluate how important a word is to a document in a collection or corpus, often used in information retrieval and text mining.

So the algorithm is as follows:

1. First we need to collect the available possible conference locations within the budget constraints.
2. We also collect the response on the possible features of the conference locations from the participants in the form of online/onsite survey or other ways.
3. Then for each possible available location, we see how many of the cumulative features are satisfied in the survey log by the location.
4. We select the location with highest number of cumulative features satisfied by it.

Figure 2 displays the pseudocode of the algorithm *MFC*.

Algorithm: *MFC*

Let *D* be the Boolean database of possible available locations; *Q* be the survey log, *A* ($a_1 \ldots a_M$) be the attributes in *D* and *Q*

For each tuple t_j in *D*
  int *count*, *total* = 0;
  For (int *i* = 1 to *M*) *//for each attribute*
    count = # of tuples in *Q* satisfied for
      $a_i = 1$
    total += *count* *//Sum count with total*
Return the tuple t_j with maximum *total*

Figure 2. Pseudocode of Algorithm *MFC*

Consider the algorithm *MFC* on the EXAMPLE 1 in Figure 1. The algorithm needs to select a tuple *t* from *D* that satisfies as many conditions or features asked by the tuples in *Q*. For tuple t_1, we can see that it satisfies total 6 cumulative tuples in *Q* as follows: 3 (q_1, q_3, q_5) for attribute/feature *Beach*, 0 for feature *WiFi*, 3 for feature *Accommodation* (q_2, q_3, q_4), 0 for feature *Intl. Airport*; the total (3+0+3+0) = 6 tuples. Similarly the tuple t_2 satisfies total 7 cumulative tuples in *Q* (3 for feature *WiFi* and 3 for feature *Intl. Airport*), tuple t_3 satisfies total 10 cumulative tuples in Q (3 for feature *WiFi*, 3

for feature *Accommodation*, and 3 for feature *Intl. Airport*), and tuple t_4 staisfies total 9 cumulative tuples in *Q* (3 for features *Beach*, 3 for feature *Accommodation*, and 3 for feature *Intl. Airport*). So the tuple t_3 covers maximum number of cumulative features (10) asked by the tuples in *Q*, so the algorithm *MFC* selects the location t_3 as the best location among the four locations (tuples) available in the database *D*.

Algorithm MFC with Budget Constraints: If we have a predefined budget limit in advance, we can eliminate the locations that do not meet the budget limit and simply employ the algorithm *MFC* as discussed above to select the best location. In case if we do not have a fixed predefined budget limit and want to maximize the participants' satisfaction as well as minimize the cost, the algorithm *MFC* can be employed to tackle the budget constraints as follows:

1. For each available location, algorithm *MFC* calculates a score as *the total number of features or attributes covered by the location* divided by *the total cost of all features the location provides*.
2. Select the location with the highest score. In this way, we are considering both the number of features covered and the total cost of a location and maximizing the features covered as well as minimizing the cost.

Algorithm based on Weighted Maximized Features Coverage (*WMFC*)

This algorithm is for the weighted version of the problem Conference Location Selection (*CLS)* described earlier. When participants respond to a survey and specify the features they like regarding to a specific location, sometimes they also want to mention the preference on each feature they select. A participant might prefer one feature over another and not the same preference for all the features. So the survey can be conducted with option for the participants to mention the weight for each feature selected and the sum of the weights for all the features a participant selects must be equal to one. In this situation, instead of simply counting the total number of features; we need to consider the weight on each feature given by the survey participants. Figure 3 illustrates a survey log where five participants mention the weights for each attribute/feature they like in terms of weight.

Tuple ID	*Beach*	*WiFi*	*Accommodation*	*Intl. Airport*
q_1	.5	.4	0	.1
q_2	0	.4	.6	0
q_3	.4	.4	.2	0
q_4	0	.2	.4	.4
q_5	.7	0	0	.3

Survey Log *Q′*

Figure 3. Survey log based on feature weight

As we can see in Figure 3, the sum of weight for each row (tuple) is equal to 1, that means a participants mention weight on each feature they like and the total weight must be equal to 1.

The algorithm *WMFC* is as follows:

1. First we need to collect the available possible conference locations within the budget constraints.
2. We also collect the response on the possible features of the conference locations from the participants in the form of online/onsite survey or other ways. The response on each feature represents the weight mentioned by the participants.
3. Then for each possible available location, we sum up the cumulative weights of features that are satisfied in the survey log by the location.
4. We select the location with highest cumulative weight of features satisfied by it.

Figure 4 displays the pseudocode of the algorithm *WMFC*.

Consider the available locations database *D* in Figure 1 and the survey log *Q′* based on weighted preference in Figure 2. The algorithm *WMFC* needs to select a tuple *t* from *D* that it satisfies as many conditions or features asked by the tuples in *Q′* based on the weighted preference. For tuple t_1, we can see that the total weights of the features satisfied by the tuples in *Q′* is as follows: total 1.6 for attribute/feature *Beach* (.5 for q_1, .4 for q_3, and .7 for q_5), 0 for *WiFi*, 1.2 for *Accommodation*, 0 for *Intl. Airport*; so the total (1.6+0+1.2+0) = 2.8. Similarly the total weight for the tuple t_2 is 2.2 (1.4 for *WiFi* and .8 for *Intl. Airport*), total

weight for the tuple t_3 is 3.4 (1.4 for *WiFi*, 1.2 for *Accommodation*, and .8 for *Intl. Airport*), and total weight for tuple the t_4 is 3.6 (1.6 for *Beach*, 1.2 for *Accommodation*, and .8 for *Intl. Airport*). So the tuple t_4 covers maximum features weight asked by the tuples in *Q'*, so the algorithm *WMFC* selects the location t_4 as the best location among the four locations (tuples) available in the database *D*.

Algorithm: *WMFC*

Let *D* be the Boolean database of possible available locations; *Q* be the survey log, *A* ($a_1 \ldots a_M$) be the attributes in *D* and *Q*; w_i (*i* = 1 to *M*) be the weight given for each attribute A_i

For each tuple t_j in *D*
  int *local_sum*, *total_sum* = 0;
  For (int *i* = 1 to *M*) *//for each attribute*
    local_sum = sum of weights for all tuples in *Q* satisfied for a_i = 1
    total_sum += *local_sum*
Return the tuple t_j with maximum *total_sum*

Figure 4. Pseudocode of Algorithm *WMFC*

So, the algorithm *MFC* is modified to *WMFC* by summing up the cumulative weights on the features instead of just counting them. The two algorithms are basically the same and *WMFC* can also be used for Boolean data (survey log) where the values or weight of each feature is either 1 or 0.

Algorithm WMFC with Budget Constraints: As discussed for algorithm *MFC*, the algorithm *WMFC* also can be employed to tackle the budget constraint by calculating score for each available location as *the sum of cumulative weights a location can satisfy* divided *the total cost of all features the location provides*. Then select the location with the highest score.

Algorithm based on Survey-Specific Scoring function (*SSF*)

We consider Top-*k* Retrieval via Survey-Specific Scoring Function. Let *Score*(*q*, *t*) be a scoring function that returns a real-valued score for any tuple *t*. Let *k* (=1) is an integer associated with a survey response *q*. Then *R*(*q*) is defined as the set of top-*k* tuples in the database with the highest scores. In our problem, *k* is equal to 1 as we try to select the best one location among the available possible locations. Note that tuples that do not satisfy all attributes specified in the query may also be returned. An example of a query specific scoring function is the dot product of *q* and *t*.

Tuple ID	*Top-1 tuple with scores*
q_1	t_2 (2)
q_2	t_3 (2)
q_3	t_1 (2)
q_4	t_3 (3)
q_5	t_4 (2)

Figure 5. Results of Top-*k* (*k*=1) Retrieval

Consider the EXAMPLE 1 illustrated in Figure 1. Assume that each tuple in the survey log returns the top-1 tuple (i.e., *k* = 1), where the survey-specific scoring function is the dot product between a survey response in *Q* and a tuple in *D*. Based on this scoring function, the results of the execution of the five survey responses are shown in Figure 5 (score ties have been broken arbitrarily).

Algorithm: *SSF*

Let *D* be the Boolean database of possible available locations; *Q* be the survey log, *A* ($a_1 \ldots a_M$) be the attributes in *D* and *Q*;

Initialize an empty buffer *B*
  //that will contain top-1 tuples with
  //corresponding scores for each tuple in *Q*

For each tuple q_j in *Q*
  Find top-1 tuple from *D* with corresponding score
  //score based on the survey-specific scor
  //ing function (dot product betn. *Q* and *D*)

  If top-1 tuple found for q_j already presents in *B*
    Add (sum) new score with the existing score for the corresponding tuple in *B*
  Else
    Insert top-1 tuple found for q_j in *B*
Return the tuple in *B* with highest score

Figure 6. Pseudocode of Algorithm *SSF*

Once we find the top-1 tuple for each survey response, the next step of the algorithm *SSF* is to find the tuple *t* with highest cumulative scores. As we can see in Figure 5 that tuple t_3

has the highest cumulative scores of 5 (2 for q_2 plus 3 for q_4). So the algorithm *SSF* returns tuple t_3 as the best location (tuple) among the available locations in database *D*.

Figure 6 displays the pseudocode of the algorithm *SSF*.

Algorithm SSF with Budget Constraints: The algorithm *SSF* can be employed to tackle the budget constraint by calculating rank for each available location as *the score calculated by the algorithm* as in Figure 6 divided by *the total cost of all features the location provides*. Then select the location with the highest rank.

Algorithm based on Skyline Semantics Approach (*SSA*)

We also consider skyline retrieval semantics for this problem. Given a set of points, the skyline comprises the points that are not dominated by other points. A point dominates another point if it is as good or better in all dimensions and better in at least one dimension (Tan, Eng, & ooi, 2001). We consider skyline for Boolean data in our problem, but to get a clear picture let consider a common example in the literature, "*choosing a set of hotels that is closer to the beach and cheaper than any other hotel in distance and price attributes respectively from the database system of the travel agents'* (Borzsonyi, Kossmann, & Stocker, 2001)". Figure 7 illustrates this case in *2*-D space, where each point corresponds to a hotel record. The *x*-axis and *y*-axis specify the room price of a hotel and its distance to the beach respectively. Clearly, the most interesting hotels are *{a*, *g*, *i*, *n}*, called *skyline*, for which there is no other hotel in *{a*, *b*, . . . , *m*, *n}* that is better on both dimensions. As mentioned earlier, we mainly consider Boolean skylines (skylines with Boolean data), where all the attributes asked by a survey response need not to be present in the tuple to be returned by the query unlike conjunctive Boolean retrieval. Consider our running example in Figure 1. Tuple q_1 in the survey log *Q* asks for the features *Beach*, *WiFi*, and *Intl. Airport*. The tuples t_2 (for features *WiFi* and *Intl. Airport*), t_3 (for features *WiFi* and *Intl. Airport*), and t_4 (for features *Beach* and *Intl. Airport*) from database *D* would appear in the skyline as there is no tuple in *D* that exactly satisfies the conditions or features asked by q_1.

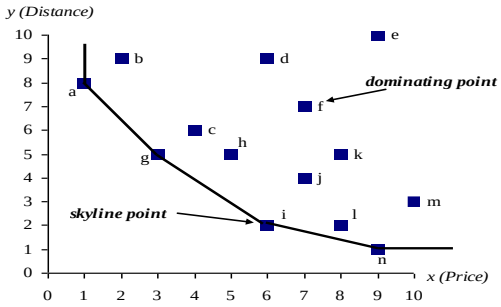

Figure 7. Skyline Example

The algorithm *SSA* works as follows:

1. We collect the available locations data base *D* and the survey log *Q*
2. Then we find the skylines (tuples for *D*) for each of the survey tuples from the survey log *Q*
3. Return the tuple in *D* that appears in most of the skylines. The tie is broken arbitrarily.

For each survey tuple *q* in the query log we define the *survey skyline S(q)* = $\{s_1 \ldots s_L\}$, which is a collection of *skyline points.* Each skyline point *s* defines a subset (i.e., projection) of attributes for which any data point (tuple) remains on the skyline. We store the data tuples from database that appear on the skylines in skyline log for each survey tuple. A skylines log contains all the skylines for the survey log. Figure 8 displays the skyline log for our EXAMPLE 1 described in Figure 1. There are several methods proposed for efficient processing of skyline queries which are mentioned in related work (Section 6). Any good skyline processing technique such as (Morse, Patel, & Jagadish, 2001) can be used here to find the skylines for the survey log which is efficient for Boolean data. Once these skylines have been found, the next step of the algorithm *SSA* is to return the tuple that appears in highest number of skylines.

Tuple ID	*Skylines (data tuples in the skyline)*
q_1	t_2, t_3, t_4
q_2	t_3
q_3	t_1 , t_3, t_4
q_4	t_3
q_5	t_4

Figure 8. Skyline Log

From Figure 8, we can see that the tuple t_3 appears in highest 4 skylines (for q_1, q_2, q_3, and

q_4). So the algorithm *SSA* selects the location t_3 as the best location among the four locations (tuples) available in the database *D*.

Figure 9 displays the pseudocode of the algorithm *SSA*.

Algorithm: *SSA*

Let *D* be the Boolean database of possible available locations; *Q* be the survey log, *S* be the skyline log for *Q* and *D*;

Find skyline log *S*
// skylines for *Q* and *D*

Return the tuple that appears in highest number of skylines in *S*

Figure 9. Pseudocode of Algorithm *SSA*

Algorithm SSA with Budget Constraints: The algorithm *SSA* can be employed to tackle the budget constraint by calculating score for each available location as *the number of skylines it appears on* as described above (Figure 9) divided by *the total cost of all features the location provides*. Then select the location with the highest score.

4. EXPERIMENTS

Our main performance indicator is the time cost of the proposed algorithms. As algorithm *WMFC* and *MFC* are basically the same, we do not show the experiment results for *WMFC*. We evaluate the time performance of three algorithms *MFC*, *SSF*, and *SSA*. We do not provide any evaluation on quality as each of the proposed algorithm is using different semantics and hence is not possible to compare them with any single optimal answer. It is up to the organizers how they want to satisfy the potential conference participants. But as mentioned above, we evaluate their time performance.

System Configuration: We used Microsoft SQL Server 2000 RDBMS on a Intel Core i7 P4 2.93-GHZ PC with 3 GB of RAM and 700 GB HDD for our experiments. Algorithms are implemented in C#.

Datasets: We used both real and synthetic data for our experiments. We randomly selected five (5) available possible locations and selected 30 possible Boolean features/attributes related to these locations such as *On-site accommodation*, *WiFi available*, *Close to international airport*, and so on. We then generated a survey with the same 30 Boolean attributes to collect data from the potential participants to express their interests on the feature/attributes level. In specific, we use two datasets: (i) *REAL*: real survey log, and (ii) *SYNTH*: synthetic survey log generated from the real survey log.

Real survey log (REAL): We collected 230 survey responses for possible future conference location from university users and friends through an online survey. The survey was designed with 30 Boolean features such as *On-site accommodation*, *WiFi available*, *Close to international airport*, and so on. Users were asked to select the features they prefer to have (positive) available in the possible conference location. The value of each feature/attribute selected was set as 1 and rest of the values as 0. Users selected 4-6 features on average. *WiFi available* and *On-site accommodation* were the most popular features.

Synthetic survey log generated from real survey log (SYNTH): As the real survey log is very small, it is inappropriate for scalability experiments. So we generated larger datasets from the real query log. A total of 100,000 survey responses were generated as follows: at each step we randomly select a survey response from the REAL survey log, randomly select two of its attributes and swap their values (1 to 0 and vice versa).

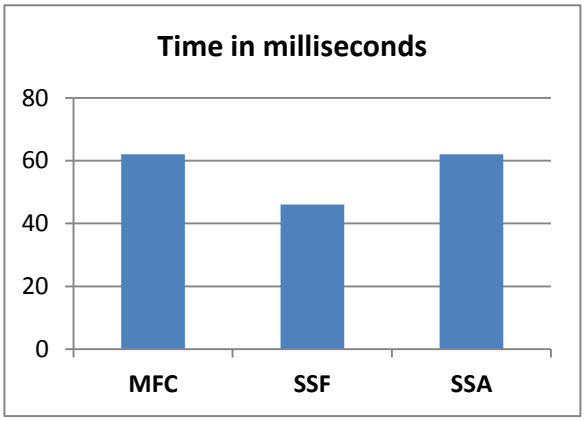

Figure 10. Time performance of the algorithms for *REAL* dataset

Figure 10 shows the time performance of the three algorithms (*MFC*, *SSF*, *SSA*) for the *REAL* dataset. The *x*-axis represents the algorithms and *y*-axis the represents the total time (in milliseconds) they take. As we can see that even the algorithm *SSF* is little faster than the other two algorithms, all the three algorithms are really very close in terms of performance. As mentioned above that the *REAL* dataset is very

small with only 230 survey responses, it is not feasible to compare the performance of the algorithms. So we also conduct experiment on larger *SYNTH* dataset discussed next.

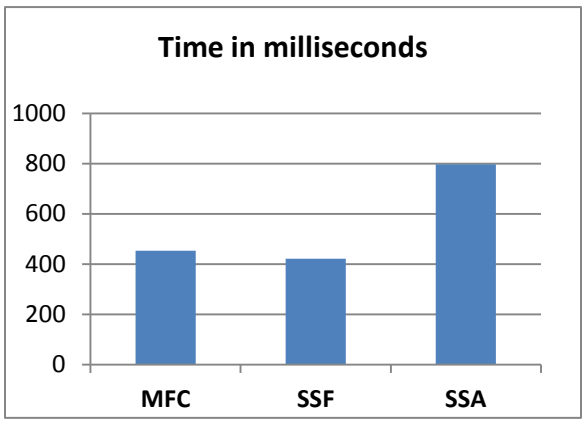

Figure 11. Time performance of the algorithms for *SYNTH* dataset

Figure 11 shows the time performance of the three algorithms for the *SYNTH* dataset. The *x*-axis represents the algorithms and the *y*-axis the represents the total time (in milliseconds) they take. As we can see that the algorithm *SSA* is little slower than the other two (*MFC* and *SSF*) and algorithms *MFC* and *SSF* take almost same time to run the experiment. The algorithm *SSA* is slower because we did not use any advanced algorithm to generate skyline log (skylines of each survey response). For this experiment we use the naïve approach comparing each tuple in the locations database for each survey response in the survey log to generate the skyline log. As mentioned in Section 4, the performance of the algorithm *SSA* can be improved by applying any effective technique to generate the skylines such as technique prposed by Morse, Patel, & Jagadish (2001).

The time performances in Figures 10 and 11 are shown in milliseconds and we can see that in fact there is not much difference in the performance of the algorithms. So, any of the algorithms can be used. But one thing to remember that each of these algorithms uses different semantics such as – algorithm *MFC* uses maximum cumulative coverage of features among all the survey responses, algorithm *SSF* uses survey-specific scoring function, and algorithm *SSA* uses skylines semantics approach. So the algorithms can select different locations based on the semantics used. In our experiment, among the available 5 locations (numbered 1, 2, 3, 4, 5), the algorithms *MFC* and *SSA* selected location number 1 as the best location whereas the algorithm *SSF* selected location number 4 as the best location. Now, it is up to the organizers which algorithm they want to use based on how they want to satisfy the potential conference participants.

5. OTHER PROBLEM VARIANTS

In this section we discuss some other interesting problem variants.

Problem Variant with Categorical Data

We consider *categorical databases*, which are natural extensions of Boolean databases where each attribute a_i can take one of several values from a multi-valued categorical domain Dom_i. A survey over a categorical database is a set of features of the form $a_i = x_i$, $x_i \in Dom_i$. We can define problem variants for categorical data corresponding to the ones for Boolean data discussed earlier.

Each categorical column a_i can be replaced by $|Dom_i|$ Boolean columns, and consequently a categorical database/survey log with M attributes is replaced by a Boolean database/survey log with $\prod_{1 \le i \le M} Dom_i$ Boolean attributes.

Problem Variant with Numeric Data

We also consider *numeric databases*. We consider surveys that specify ranges over a subset of attributes. The above problem variants for Boolean data have corresponding versions for numeric databases. For example, features may be specified with ranges on *price*, *distance from the airport*, *number of on-site accommodations available*, etc, and the returned results may be ranked by *price*.

Problems involving numeric ranges can be reduced to Boolean problem instances as follows. We first execute each survey response in the survey log, and reduce Q to Q'' by eliminating survey response for which the new tuple has no chance of entering into the top-k results. Then, for each numeric attribute a_i in Q'', we replace it by a Boolean attribute b_i as follows: if the i^{th} range condition of tuple q in Q'' contains the i^{th} value of tuple t in locations database D, then assign 1 to b_i for tuple q, else assign 0 to b_i for tuple q (i.e., each survey response has effectively been reduced to a Boolean row in a Boolean survey log Q''). The tuple t in locations database D can be converted to a Boolean tuple consisting of all 1's.

Problem Variant with Text Data

A text database consists of a collection of documents, where each document is modeled as a bag of words as is common in Information Retrieval. Tuples or survey responses are sets of keywords, with top-*k* retrieval via query-specific scoring functions, such as the tf-idf-based BM25 scoring function (Robertson & Walker, 1994). The Boolean problem discussed above can be directly mapped to a corresponding problem for text data if we view a text database as a Boolean database with each distinct keyword considered as a Boolean attribute. All the algorithms developed for Boolean data can be used for text data. However, if we view each distinct keyword in the text corpus (or survey log) as a distinct Boolean attribute, the dimension of the Boolean database is enormous. Consequently, none of the algorithms described above might be feasible for text data. We may need to develop new effective algorithms for text data and we plan to work on this in the future. In the future, we also intend to develop more effective algorithms for other data types described above such as categorical and numerical data.

Dependencies among Features/Attributes

Another problem variant arises when there are dependencies among the features/attributes. E.g., if a location has the *WiFi* feature available, it must also have *Internet* feature. We tackle this by removing the unsatisfiable tuples (survey responses) from the survey log and using the dependencies to optimize the algorithms.

6. RELATED WORK

Optimal product design or positioning is a well studied problem in Operations Research and Marketing which seems similar to our problem. Shocker & Srinivasan (1974) first represented products and consumer preferences as points in a joint attribute space. After that, several approaches and algorithms (Albers & Brockhoff, 1977 & 1980, Albritton & McMullen, 2007, Gavish, Horsky, & Srikanth, 1983, Gruca & Klemz, 2003, Kohli & Krishnamurti, 1989) have been developed to design/position a new product. Works in this domain require direct involvement (one or two step) of consumers and users are usually shown a set of existing alternative products to choose or set preferences. Like our work, users in fact do not get to select the attributes or features they like. Also we do not show the available locations to the users/participants instead collect their preferences on possible features level. We use previous user survey logs and it is easy to collect the preferences for large number of Internet users nowadays.

We use skyline semantics in one of our proposed algorithms, *SSA*. Several techniques have been proposed for efficient skyline query processing (Borzsonyi & Stocker, 2001, Kossmann, Ramsak, & Rost, 2002, Papadias, Tao, Fu, & Seeger, 2003, Tan, Eng, & Ooi, 2001, Sarkas, Das, Koudas, & Tung, 2008). Skyline computation over low cardinality domains (Morse, Patel, & Jagadish, 2001) also considers skyline for Boolean data as well. One main difference of our work with the existing works is that our goal is not to propose a method for processing or maintaining the skylines, instead we use skylines as a semantic where a new tuple/location can be satisfied to maximum number of potential participants.

Miah, Das, Hristidis, & Mannila (2008) tackled a related problem of maximizing the visibility of an existing object by selecting a subset of its attributes to be advertised. The main problem was: given a query log with conjunctive query semantics and a new tuple, select a subset of attributes to retain for the new tuple so that it will be retrieved by the maximum number of queries. In this paper, we consider selecting a location (tuple) from the given locations, and not selecting subset of attributes/features.

7. CONCLUSIONS AND FUTURE WORK

In this work, we investigate the problem of selecting a good conference location within budget constraints considering participants' interests on the features a location might have. The goal is to satisfy as many potential participants as possible to attract them to submit papers, arrange workshops, giving tutorials, and attend the conference. The problem also has interesting applications in information systems education such as designing an information systems course that can attract students and meets industry demands. We develop several effective algorithms that work well in practice as well as for large data. We evaluate the algorithms both on real and synthetic data. In the future we plan to develop effective algorithms for different data types such as text, categorical and numerical data.

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Additional Support for the Information Systems Analyst Exam as a Valid Program Assessment Tool

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Abstract

This paper presents a statistical analysis to support the notion that the Information Systems Analyst (ISA) exam can be used as a program assessment tool in addition to measuring student performance. It compares ISA exam scores earned by students in one particular Computer Information Systems program with scores earned by the same students on the Major Field Test (MFT). The paper shows that the ISA Exam appears to measure knowledge retention in the same manner as the MFT. Since the MFT is recommended as a valid program assessment tool, the ISA Exam should be similarly recommended.

Keywords: Program assessment, Information Systems Analyst (ISA), Major Field Test (MFT)

1. INTRODUCTION

The Information Systems Analyst (ISA) Exam is designed as an exit examination over the material covered by the IS2002 Model Curriculum that is jointly sponsored by the Association for Computing Machinery (ACM), Association for Information Technology Professionals (AITP), and Association for Information Systems (AIS). It is jointly administered by the Institute for Certification of Computer Professionals (ICCP) and one of ICCP's divisions, the Center for Computing Education Research (CCER). Those who hold a bachelor degree and score sufficiently highly on the ISA exam qualify to be certified as an ISA-Practitioner (50% score) or ISA-Mastery (70% score) (CCER, 2010; ICCP, 2010).

The ISA Exam is considered to be a good tool by which to assess students' learning in under-graduate CIS programs. Similarly, Educational

Testing Service's Major Field Test (MFT) (ETS, 2010) is considered a good measurement of students' knowledge retention in specific academic disciplines. Moreover, the MFT is also considered to be a good measure of program assessment.

The issue addressed by this article is whether it is valid to use the ISA exam for program assessment in addition to student assessment. Two references were found in the literature on this topic (Carpenter, et al., 2009; Segall, et al., 2009). This article builds on the former by providing additional statistical support for the ISA exam as a program assessment tool.

2. LITERATURE REVIEW

Program assessment is a critically important activity within quality educational institutions. It measures the contribution that a program makes to students' learning, thereby insuring quality of graduates. Ultimately, though, Palomba & Banta (1999) insist the emphasis of program assessment is on programs rather than individual students. The Association to Advance Collegiate Schools of Business (AACSB) requires program assessment of its accredited programs in order to show evidence of program quality and to establish internal systems for quality improvement (AACSB, 2006).

Program assessment is done in a variety of manners using a wide range of methodologies. Those include: interviewing stakeholders in the capstone course (Payne, Whitfield & Flynn, 2002), recording multiple incidents or "occasions" throughout the program (Moberg & Walton, 2003), centering on course syllabi (Cunningham & Omaoayole, 1998), examining critical incidents throughout a program (Bycio & Allen, 2004), evaluating by student peers (Aurand & Wakefield, 2006), gathering feedback from alumni and employers (Dyke & Williams, 1996), and focusing on competencies (Roberson, et al., 2002). Strong support for multifaceted methods of program assessment exists in Young (1996), Palomba & Palomba, (1999), Mirchandani, Lynch & Hamilton (2001).

The Mirchandani, et al., multifaceted approach (2001) includes the use of the MFT exam. Others who support the use of the MFT as part of program assessment include Black & Duhon (2003), Karanthonos (1991), and Manton & English (2002). Black & Duhon (2003) go on to suggest the use of other objective tests that measure specific competencies.

The ISA Exam is one such objective test that purports to measure the specific competencies included in the IS2002 Model Curriculum (CCER, 2010). Many programs that adhere to that model curriculum do indeed use the ISA Exam as a measure of student performance in the program. That is endorsed by Kamoun & Selim (2008), Laudry, et al. (2008), and Wagner, et al. (2008).

Only two references were found that advocate the use of the ISA Exam as means of program assessment in addition to assessment of individual students. Segall, et al., (2009) explain a database approach for matching the results of the ISA exam to the learning units of the IS2002 Model Curriculum. In that sense, the ISA exam results are indeed being used to assess the program itself as well as students within the program.

Carpenter, et al. (2009) described a pre-test, post-test study using the ISA Exam for program assessment. In that 2003-2007 study, thirty-five students took the ISA exam twice, first as underclass members and second as graduating seniors. The mean ISA Exam scores for the second test were indeed statistically significantly higher than for the second test. That alone indicates that the intervening courses in that particular CIS program did add to the knowledge retention of those students. That is a positive indicator for the assessment of the program.

In the Carpenter, et al. (2009) study, fifty-one students took both the ISA exam and the MFT. The means percentile scores for those students were seen to be equal. Their conclusion is that "the ISA and MFT have equal value in terms of their usability as valid measurements for assessment purposes." (p. 358).

3. RESEARCH METHODOLOGY

The logic that flows from the Literature Review is as follows. Since MFT is widely recognized as a valid means of program assessment, if the ISA Exam does indeed demonstrate student knowledge retention in the same manner as does the MFT, then the ISA Exam should be considered in similar light as a valid program assessment tool.

The null hypothesis is that students who took just the ISA Exam performed statistically equally (using percentile scores) as those students who took both the ISA Exam and the MFT. Failure to reject the null hypothesis would indicate that the ISA measures student retention of knowledge

from the CIS courses in the same manner as does the MFT for business courses. Thus, hypothesis 1 (H_1) is:

$$H_0: \mu_{ISA\ \&\ MFT} = \mu_{ISA}$$

$$H_A: \mu_{ISA\ \&\ MFT} \neq \mu_{ISA}$$

This study includes one hundred and three students in a computer information systems program in a western state college who took the ISA Exam between 2003 and 2010. Thirty-one of those students took only the ISA Exam. Seventy-two of the students took both the ISA Exam and the MFT.

Next, the researchers must measure whether the ISA percentile scores of the two groups of students can be considered statistically equal. This would indicate whether there is some anomaly in one group or the other. Only then can the ISA and MFT percentile scores of those who took both exams be compared to each other. Thus, hypothesis 2 (H_2) is:

$$H_0: \mu_{ISA} = \mu_{MFT}$$

$$H_A: \mu_{ISA} \neq \mu_{MFT}$$

Other interesting aspects were also explored. Specifically tests were run to determine what portion of the variability in the ISA Exam scores are explained by the MFT scores, and whether the students' graduating grade point average (GPA) explains any of the variability in ISA Exam scores was also considered.

Data for the study were taken from reports provided to the college by the Educational Testing Service (ETS) for the MFT exam and by Center for Computing Education Research (CCER) for the ISA exam. Data were analyzed using Microsoft Excel 2007 and SPSS 15.0 for Windows. A 95% confidence level was used for all tests and reported results.

4. FINDINGS

Table 1

F Test for Differences in Two Variances	
F Test Statistic	1.0798441
Two-Tail Test	
Lower Critical Value	0.5214404
Upper Critical Value	1.776174
p-Value	0.7709159

To test whether the two groups of students (the thirty-one who took only the ISA Exam versus the seventy-two who took both the ISA Exam and the MFT) are statistically equal, an F-Test was run to determine whether the variances in the scores are statistically equal. Table 1 illustrates that the variances are statistically equal, so the researchers then ran a two-sample t-test that assumes statistically equal variances. Table 2 illustrates that mean ISA exams of the two groups are statistically equal. Findings of Tables 1 and 2 combined indicate that there is no anomaly in the two groups, so that the ISA Exam scores can be considered to be valid for those who took both the ISA Exam and the MFT, supporting the null hypothesis for H_1. This enables the researchers to continue with further comparison of the ISA Exam percentile scores to the MFT percentile scores of that group of seventy-two CIS students.

Table 2

t-Test: Two-Sample Assuming Equal Variances		
	ISA	*ISA & MFT*
Mean	60	58.25
Variance	733.13333	678.725352
Observations	31	72
Pooled Variance	694.88614	
Hypothesized Mean Difference	0	
Df	101	
t Stat	0.3090365	
P(T<=t) one-tail	0.3789652	
t Critical one-tail	1.6600806	
P(T<=t) two-tail	0.7579304	
t Critical two-tail	1.9837309	

Table 3

F Test for Differences in Two Variances	
F Test Statistic	1.057621
Two-Tail Test	
Lower Critical Value	0.625649
Upper Critical Value	1.59834
p-Value	0.81407

Moving on to a comparison of the ISA Exam percentile scores and the MFT percentile scores of the seventy-two students who completed both

exams, the researchers first conducted an F-test to determine if the variances are statistically equal. The results indicate that they are statistically equal as shown in Table 3.

Equality of variances leads to the two-sample t-test that assumes equal variances for the null hypothesis that ISA Exam percentile scores and MFT percentile scores are statistically equal for the same set of students. The results indicate that the percentile scores are indeed statistically equal. The results of the t-test are given in Table 4.

Table 4

t-Test: Two-Sample Assuming Equal Variances		
	ISA	*MFT*
Mean	58.25	61.84722222
Variance	678.725352	717.7650626
Observations	72	72
Pooled Variance	698.245207	
Hypothesized Mean Difference	0	
Df	142	
t Stat	-0.81679776	
P(T<=t) one-tail	0.20770612	
t Critical one-tail	1.65565517	
P(T<=t) two-tail	0.41541223	
t Critical two-tail	1.97681096	

These results indicate that the ISA exam can be utilized as an assessment instrument, as the student group who took both exams placed in the same percentile for both exams, and has been verified over time. This indicates that the students' retained knowledge is being measured in a parallel manner between disciplines. This is not surprising, as both tests are nationally normed, and the ISA Exam is built around the IS2002 curriculum model, which standardizes the coursework and the knowledge base of the curriculum.

As a further exploration and verification of this relationship, a scatter plot of the ISA scores versus the MFT scores is given in Figure 1 in the Appendix. This figure illustrates a positive trend in exam performance by students. The slope indicates that for every percentage point increase in the MFT Exam score, a 0.81 percentage point increase in the ISA Exam score is attained. A correlation coefficient of r = 0.8235 confirms this, and a coefficient of determination of R^2 = 0.6782 tells one that 67.82% of the ISA performance can be described by the MFT performance.

Other factors that could drive this relationship could be:

- students' graduating GPA
- CIS coursework GPA
- the students' employment status
- the students' marital/family status
- students' test-taking ability
- course repeat for improved GPA
- multiple majors being pursued

These variables could increase the R^2 value in a multiple linear regression model, and contribute to the explanatory nature of the model.

The only one of the above data to which the researches had access was overall GPA. A graph of the GPA versus ISA percentile is given as Figure 2 in the Appendix. The results are to be expected in that a higher GPA indicated a higher ISA percentile. Reading the regression statistics one can conclude that for every point increase in the students' GPA, a 35 percentile point increase in the ISA Exam score was accomplished.

Addition of the graduating GPA to the regression model yields:

$$y = -32.52 + 0.68\,x_1 + 13.75\,x_2$$

where

$$y = ISA\ percentile$$

$$x_1 = MFT\ percentile$$

$$x_2 = Graduating\ GPA$$

$$and\ R^2 = 0.72$$

This multiple regression model now determines 72% of the variation in the ISA exam percentile as a function of the MFT percentile and the students' graduating GPA. The remaining 28% could be due to the factors listed above, or other factors yet to be determined. The slight addition to the R^2 value is most likely a result of GPA measuring knowledge as it is acquired, while the MFT and ISA exams measure knowledge as it is retained.

5. CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

This study demonstrates that the ISA Exam indicates students' knowledge retention in the

same sense that the MFT does. Therefore, in addition to being a means of assessing student performance, the ISA Exam can be used as a program assessment tool in the same sense the MFT is used.

A limitation of this study lies in the number of students involved. While the sample size is sufficient to justify these statistical tests and conclusions, it is not large enough to draw conclusions about all programs.

Another potential limiting factor is the nature of the college in which this study was conducted and of the students at that institution. While, no anomaly in the college or students is perceived, yet the students annually score higher as a group than the average score for all who have taken the ISA Exam each year.

A third limiting factor relates to the use of MFT overall scores. This study might have yielded different results if data were used for an information systems subset of questions of the MFA. However, such data were not available at the subject institution.

If similar data exist at other institutions, this research can be easily replicated. If similar results are produced by those replications, the limitations of this particular study are overcome. The authors encourage the Center for Computing Education Research (CCER) to sponsor such research efforts.

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7. APPENDIX

Figure 1

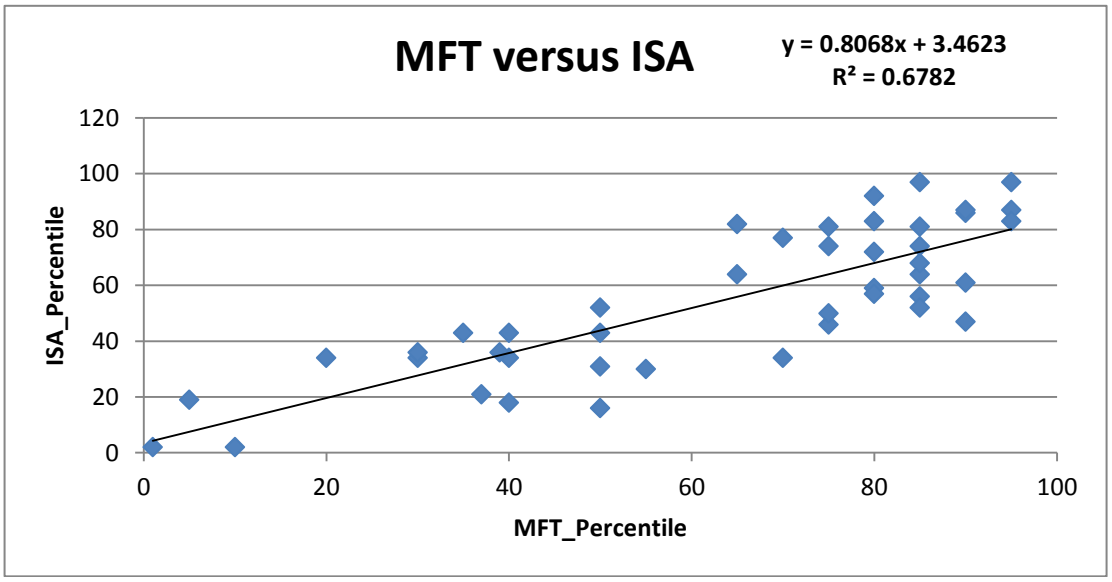
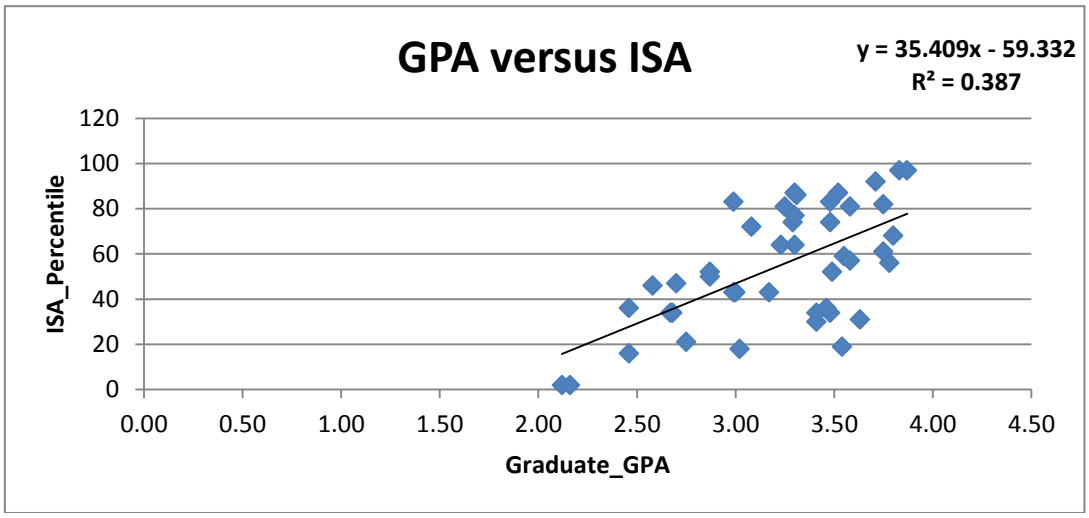


Figure 2



Teaching Case

Solving Relational Database Problems with ORDBMS in an Advanced Database Course

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Abstract

This paper introduces how to use the object-relational database management system (ORDBMS) to solve relational database (RDB) problems in an advanced database course. The purpose of the paper is to provide a guideline for database instructors who desire to incorporate the ORDB technology in their traditional database courses. The paper presents how to use the specific object-relational database (ORDB) technology to solve three normalization problems: Transitive dependency, Multi-value attributes, and Non-1st Normal Form. The paper also provides the solutions to data complexity problems with three specific ORDBMS techniques: object view, object inheritance, and object integration. The paper summarizes the significance and advantages of teaching ORDBMSs in advanced database courses. Course contents and students' learning outcomes are discussed. To be more helpful to database educators, the paper presents a complete object-relational database development case study from the UML class diagram design to Oracle ORDBMS implementation.

Keywords: Object-relational database, Database Curriculum, Oracle Database, Normalization

1. INTRODUCTION

The success of relational database management systems (RDBMSs) cannot be denied, but they experience difficulty when confronted with the kinds of "complex data" found in advanced application areas such as hardware and software design, science and medicine, and mechanical and electrical engineering. To meet the challenges, Oracle, IBM and Microsoft have moved to incorporate object-oriented database features into their relational DBMSs under the name of object-relational DBMSs. The major database vendors presently support object-relational data model, a data model that combines features of the object-oriented model and relational model (Silberschatz, et al., 2009). The emergence of object-relational technology into the commercial database market has caused the database professional's attention in seeking how to utilize its object-oriented features in the database development and has brought new challenges for IS instructors in teaching ORDBMS in their database courses. In response to this challenge, the author has incorporated the ORDB technology into her advanced database course. ORDBMS enhances object-oriented technology into the relational database management system (RDBMS) and extends traditional RDBMS with object-oriented features. As an evolutionary technology, ORDBMS allows users to take advantages of reuse features in object-oriented technology, to map objects into relations and to maintain a consistent data structure in the existing RDBMS.

The purpose of the paper is to provide a guide for database instructors who desire to incorporate the ORDB technology in their traditional database courses. This paper presents how to use ORDBMS to overcome relational database weaknesses and solve some existing normalization problems. The paper first introduces the background and features of ORDBMS, then presents how to use the specific ORDBMS techniques to solve normalization problems in 1) Transitive dependency, 2) Multi-value attributes, 3) and Non-1st Normal Form, and how to use the specific ORDBMS features: 1) object view 2) object inheritance and 3) object integration to solve data complexity problems. Course content and students' learning outcomes are discussed. Many of the ORDBMS features appear in Oracle. Thus, the author utilizes Oracle as a tool to demonstrate how to overcome some weaknesses of relational DBMS. The ORDBMS script in the case study has been tested in the Oracle 9i, 10g, and 11g SQLPlus environment. The solution to the presented case can be utilized in the classroom demonstration and can also be generalized the homework assignments and projects of advanced database courses.

2. ORDB TECHNOLOGY

The object-relational database technology occurrence can be traced back to the middle of 1990s after emergence of object-oriented database (OODB). In their book "Object-relational DBMSs: the Next Great Wave", Stonebraker and Moore (1996) define their four-quadrant view (two by two matrix) of the data processing world: relational database, object-relational database, data file processing, and object-oriented database. Their purpose is to indicate the kinds of problems each of four-quadrants solves. As will be seen, "one size does not fit all"; i.e. there is no DBMS that solves all the applications. They suggest that there is a natural choice of data manager for each of the four database applications. They conclude why the problems addressed by object-relational DBMSs are expected to become increasingly important over the next decade. As such, it is "the next wave".

Theoretically, as Stonebraker and Moore (1996) predict in their four-quadrant view of the database world, ORDBMS has been the most appropriate DBMS that processes complex data and complex queries. The object-oriented database management systems have made limited inroads during the 1990's, but have since been dying off. Instead of a migration from relational to object-oriented systems, as was widely predicted around 1990, the vendors of relational systems have incorporated many object-oriented database features into their DBMS products. As a result, many DBMS products that used to be called "relational" are now called "object-relational." (Garcia-Molina, *et al.* 2003).

Practically, ORDBMS bridges the gap between OODBMS and RDBMS by allowing users to take advantage of OODB'MSs great productivity and complex data type without losing their existing investment in relational data (Connolly & Begg, 2006). In fact, an ORDBMS engine supports both relational and object-relational features in an integrated fashion (Frank, 1995). The underlying ORDB data model is relational because object data is stored in tables or columns. ORDB designers can work with familiar tabular structures and data definition languages (DDLs) while assimilating new object-oriented features (Krishnamurthy et al., 1999).It is essentially a relational data model with object-oriented extensions. In response to the evolutional change of ORDB technology, SQL:1999 started supporting object-relational data modeling features in database management standardization and SQL:2003 continues this evolution. Currently, all the major database vendors have upgraded their relational database products to object-relational database management systems to reflect the new SQL standards (Hoffer et al., 2009) and use by industrial practitioners.

Although each of the object-relational DBMS vendors has implemented OO principles: encapsulation and inheritance in their own way, all of them share the combination of the OO principles and follow SQL standardization, incorporate object-oriented paradigms. All the ORDBMSs have the ability to store object data and methods in databases. Many of the SQL:2003 standard ORDBMS features appear in Oracle. These features are listed as follows.

***Object Types*:** User-defined data types (UDT) or abstract types (ADT) are referred to as object types.

Functions/Methods: For each object type, the user can define the methods for data access. Methods define the behavior of data.

***Varray*:** The varray is a collection type that allows the user to embed homogenous data into an array to form an object in a pre-defined array data type.

Nested table: A nested table is a collection type that can be stored within another table. With a nested table, a collection of multiple columns from one table can be placed into a single column in another table.

***Inheritance*:** With Object type inheritance, users can build subtypes in hierarchies of database types in ORDBs.

***Object View*:** Object view allows users to develop object structures in existing relational tables. It allows data to be accessed or viewed in an object-oriented way even if the data are really stored in a traditional relational format.

There is some research that has been done in ORDBMS technology as ORDBMSs have become commonplace in recent years. He and Darmont (2005) propose the Dynamic Evaluation Framework (DEF) that simulates access pattern changes using configurable styles of change. Pardede, Rahayu, & Taniar (2006) propose an innovative methodology to store XML data into new ORDB data structures, such as user-defined type, row type and collection type. The methodology has preserved the conceptual relationship structure in the XML data, including aggregation, composition and association. Wok (2007) and Cho, et. al. (2007) present a methodology for designing proper nesting structures of user-defined types in object-relational database. The proposed schema trees schema are transformed to Oracle 10g. Their purpose is to develop an automatic ORDB design tool.

But very little research has been done in using ORDBMS to overcome relational database weaknesses and solve some existing normalization problems. The significance of the paper is to promote teaching ORDBMS features for problem solving and object reuse and integration among IS educators. The use of ORDBMSs to develop database applications can enforce the reuse of varying user-defined object types, provide developers' an integrated view of data and allow multiple database applications to operate cooperatively. Ultimately, this can result in improved operational efficiency for the IT department, increase programmers' productivity, lower development effort, decrease maintenance cost, reduce the defect rate, and raise the applications' reliability. If multiple database applications use the same set of database objects in ORDBMS, a de facto standard for the database objects is created, and these objects can be extended, reused and integrated in the ORDB.

3. CASE STUDY

3.1 Case Scenario

Pacific Bike Traders assembles and sells bikes to customers. The company currently accepts customer orders online and wants to be able to track orders and bike inventory. The existing database system cannot handle the current transaction volume generated by employees processing incoming sales orders. When a customer orders a bike, the system must confirm that the ordered item is in stock. The system must update the available quantity on hand to reflect that the bike has been sold. When Pacific Bike Traders receives new shipments, a receiving clerk must update the inventory to show the new quantity on hand. The system must produce invoices and reports showing inventory levels.

3.2. Business Rules

The following business rules are developed for the new database system:

One customer may originate many orders.
One order must be originated from a customer.

One order must contain one or more bikes.
One bike may be in many orders.

One employee may place many orders.
One order must be placed by an employee.

One bike is composed with a front wheel, rear wheel, crank, and stem.
One front wheel, rear wheel, crank, and stem compose one bike.

One employee must be either a full-time or part-time.
One full-time or part-time employee must be an employee.

3.2. ORDB Design

The Pacific Trader Object-Relational Database design is illustrated with the UML class diagram

in Appendix 1. Each of the classes is displayed as a rectangle that includes three sections: the top section gives the class name; the middle section displays the attributes of the class; and the last section displays methods that operate on the data in the object. Associations between classes are indicated with multiplicity ("min..max." notation). Inheritance is indicated with an empty triangle. Aggregation is marked with an empty diamond, whereas composition is marked with a solid diamond. Aggregation models a whole-part relationship where individual items become elements in a new class. In Appendix 1, a sales order is made of line items (bikes). Aggregation is indicated by a small empty diamond next to the SalesOrder class. The dotted line links to the associative class generated from the many-to-many relationship.

Based on the Pacific Trader's Object-Relational Database Design in Appendix 1, ORDB features are implemented with Oracle for the case in the following sections. The implementation shows how the UML class diagram maps and supports major ORDB features. For the sake of simplicity, it is assumed that referential integrity constraints will be added later.

4. ORDBMS FOR NORMALIZATION

Normalization is a logical data modeling technique for the development of a well structured relational database. The process is decomposing tables with anomalies to produce smaller tables. Traditional normalization processes are normalizing tables in non-1NF form and multi-value attributes to at least 3NF; and removing transitive dependency. Such processes can be eliminated if ORDB technology is used.

4.1. Object Type & Transitive Dependency

The address attribute is usually split into four columns such as street, city, state and zip code in order to store address dada in a customer table since it is a composite attribute in a traditional database.

Customer table

Cu_id	First	Last	Street	City	State	Zip
1	John	Smih	12 Pine	Bell	CA	90201
2	Mary	Fox	6 Circle	Brea	CA	92821

The above Customer table is in Second Normalization Form (2NF) and violates the Third Normalization Form (3NF) rule because there is the transitive dependency in the customer table. Zip is a determinant of street, city and state. Functional dependency analysis shows transitive dependency:

Zip -> Street, City, State (transitive dependency)

There are three solutions to this transitive dependency problem. Solution 1 keeps the customer table in the Second Normalization Form (2NF) though it is not an ideal normal form for a relational database.

Solution 2 is to create a new customer address table by splitting the address from the original customer table (3NF). This solution implies more joins of records in the Customer table and Zip table.

Customer Table

Cu_id	First	Last	Zip
1	John	Smith	90201
2	Mary	Fox	92821

Zip Table

Zip	Street	City	State
96123	12 Pine	Bell	CA
25678	6 Circle	Brea	VA

Solution 3 is to store all the customer address information in one column. This solution creates difficulty in data retrieval. For example, it is impossible to retrieve or sort customer records by city, state or zip code.

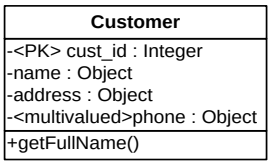
Customer table

Cu_id	First	Last	Address
1	John	Smith	12 Pine, Bell, CA 90201
2	Mary	Fox	6 Circle, Brea, CA 92821

None of the above three solutions is considered ideal in terms of efficient database design and operations. The first solution is not satisfactory since 2NF is not ideal for relational database design. The second solution implies that more joins might occur in the query process, since the zip table has been added to the database. The third solution creates difficulty in data retrieval. For example, it is impossible to retrieve or sort customer records by city, state, or zip code.

With ORDBMS technology, the attribute address can be defined as a user-defined abstract data type with a number of attributes using s the same internal format. User-defined types (UDT) or abstract data types (ADT) are referred to as object types. Object types are used to define

either object columns or object tables. The following UML Customer class illustrates the address object column.



Object types need to be defined before the customer table. The following SQL statements define the object types: address_ty and name_ty.

```
CREATE OR REPLACE TYPE address_ty AS OBJECT
(street          NVARCHAR2(30),
 city            VARCHAR2(25),
 state           CHAR(2),
 zip             NUMBER(10));

CREATE OR REPLACE TYPE name_ty AS OBJECT
(
f_name    VARCHAR2(25),
l_name    VARCHAR2(25));
```

Mapping the above customer class, the following statement is used to create the Customer table with the CustName and CustAddress object columns using name_ty and address_ty. The column phone is to be added to the table later.

```
CREATE TABLE Customer2(
Cust_ID          Number(5),
CustName         name_ty,
CustAddress      address_ty);
```

Object type constructors are used to insert object data into the table. The following INSERT statement uses constructors name_ty() and address_ty() to add data into the two object columns.

```
INSERT INTO Customer VALUES (1,
name_ty ('John', 'Smith',),
address_ty ('12 Road', 'Bell', 'CA', 90201));
```

The following statements retrieve the data from the Customer2 table.

```
SELECT c.custName.l_name, c.custAddress.City,
c.custAddress.state
          FROM Customer2 c;
```

CUSTNAME.L_NAME	CUSTADDRESS.CITY	CU
John Smith	Bell	CA

SELECT * from Customer2;

CUST_ID	CUSTNAME(F_NAME, L_NAME, INITIALS)	CUSTADDRESS(STREET, CITY, STATE, ZIP)
1	NAME_TY('John', 'Smith')	ADDRESS_TY('12 Pine', 'Bell', 'CA', 90201)

4.2 Varray and Multi-value Attributes

In a relational model, multi-valued attributes are not allowed in the first normalization form. The traditional solution to the problem is that each multiple-valued attribute is handled by forming a new table in a relational database. If a table has five multi-valued attributes, that table would have to be split into six tables. The Oracle ORDBMS allows users to create the varying length array (VARRAY) data type as a new data storage method for multi-valued attributes. The following statement defines a varray type of three VARCHAR2 string named varray_phone_ty to represent a list of phone numbers.

VARRAY is a collection type in ORDBMSs. A VARRAY consists of a set of objects that have the same predefined data type in an array. In a relational model, multi-valued attributes are not allowed in the first normalization form. The solution to the problem is that each multiple-valued attribute is handled by forming a new table. If a table has five multi-valued attributes, that table would have to be split into six tables after the First Form of normalization. To retrieve the data back from that original table, the student would have to do five joins across these six tables. ORDBMs allow multi-valued attributes to be represented in a database. ORDBMSs allow users to create the varying length array (VARRAY) data type can be used as a new data storage method for multi-valued attributes. The following statement defines a VARRAY type of three VARCHAR2 strings named varray_phone_ty to represent a list of three phone numbers in the Customer2 table.

```
CREATE TYPE varray_phone_ty AS VARRAY(3)
OF VARCHAR2(14);

ALTER TABLE Customer ADD (phones
varray_phone_ty);
```

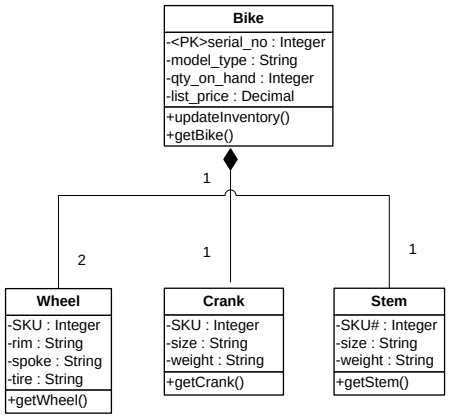
```
UPDATE customer
        SET phones =
(varray_phone_ty('(800)555-1211',
'(800)555-1212','(800)555-1213'))
        WHERE cust_id = 1;

INSERT INTO customer(phones) values
(varray_phone_ty('(800)555-
1211','(800)555-1212','(800)555-1213'));
```

The above example shows that using the varying length array (VARRAY) data type not only can solve multi-value attribute problem for the customer table, but also can speed up the query process on customer data.

4.3 Nested Table and Non-1NF

A nested table is a table that can be stored within another table. With a nested table, a collection of multiple columns from one table can be placed into a single column in another table. Nested tables allow user to embed multi-valued attributes into a table, thus forming an object.




```
CREATE TYPE wheel_type AS OBJECT(
        SKU       VARCHAR2(15),
        rim       VARCHAR2(30),
        spoke     VARCHAR2(30),
        tire      VARCHAR2(30));

CREATE TYPE crank_type AS OBJECT
        (SKU          VARCHAR2(15),
        crank_size        VARCHAR2(15),
        crank_weight      VARCHAR2(15) );

CREATE TYPE stem_type AS OBJECT(
        SKU       VARCHAR2(15),
        stem_size           VARCHAR2(15),
        stem_weight     VARCHAR2(15));
```

The following statement creates nested table types: wheel_type, crank_type and stem_type:

```
CREATE TYPE nested_table_wheel_type AS
TABLE OF wheel_type;

CREATE TYPE nested_table_crank_type AS
TABLE OF crank_type;

CREATE TYPE nested_table_stem_type AS
TABLE OF stem_type;
```

The following example creates the table named Bike with that contains four nested tables:

```
CREATE TABLE bike   (
serial_no       INTEGER PRIMARY KEY,
        model_type              VARCHAR2(20),
        front_wheel
        nested_table_wheel_type,
    rear_wheel
        nested_table_wheel_type,
    crank
        nested_table_crank_type,
    stem
        nested_table_stem_type
        )
        NESTED TABLE
                front_wheel
        STORE AS
                front_wheel,
    NESTED TABLE
                rear_wheel
        STORE AS
                rear_wheel,
        NESTED TABLE
                crank
        STORE AS
                nested_crank,
        NESTED TABLE
                stem
        STORE AS
                nested_stem;

INSERT INTO bike VALUES (1000, 'K2 2.0 Road',
nested_table_wheel_type(   wheel_type('w7023',
'4R500', '32 spokes', '700x26c' )),
nested_table_wheel_type(
wheel_type('w7023',    '4R500',    '32    spokes',
'700x26c' )),
nested_table_crank_type(
crank_type('c7023', '30X42X52', '4 pounds')),
nested_table_stem_type(
stem_type('s7023', 'M5254', '2 pounds')));
```

Finally the previous statement inserts a row into the Bike table with nested tables using the three

defined constructors: wheel_type, crank_type and stem_type.

The above example shows that using the NESTED TABLE can implement the composition association, store multiple parts and also speed up the data retrieval speed for the Bike table. The following statement shows the nested tables in the table Bike.

```
SELECT * from bike;
```

SERIAL_NO	MODEL_TYPE	FRONT_WHEEL(SKU, RIM, SPOKE, TIRE)	REAR_WHEEL(SKU, RIM, SPOKE, TIRE)	CRANK(SKU, CRANK_SIZE, CRANK_WEIGHT)	STEM(SKU, STEM_SIZE, STEM_WEIGHT)
1000	K2 2.0 Road	NESTED_TABLE_WHEEL_TYPE(WHEEL_TYPE('w7023', '4R500', '32 spokes', '700x26c'))	NESTED_TABLE_WHEEL_TYPE(WHEEL_TYPE('w7023', '4R500', '32 spokes', '700x26c'))	NESTED_TABLE_CRANK_TYPE(CRANK_TYPE('c7023', '30X42X52', '4 pounds'))	NESTED_TABLE_STEM_TYPE(STEM_TYPE('s7023', 'M5254', '2 pounds'))

5. ORDBMS FOR OBJECT INTEGRATION

The beauty of ORDBMSs is reusability and sharing. Reusability mainly comes from storing data and methods together in object types and performing their functionality on the ORDBMS server, rather than have the methods coded separately in each application. Sharing comes from using user-defined standard data types to make the database structure more standardized (Breg & Connolly. 2010)

5.1. Object Views on a Relational Table

Object views are virtual object tables, which allow database developers to add OOP structures on top of their existing relational tables and enable them to develop OOP features with existing relational data. The object view is a bridge between the relational database and OOP. Object view creates a layer on top of the relational database so that the database can be viewed in terms of objects (Loney & Koch, 2002). This enables you to develop OOP features with existing relational data. The following statements show how to create the SalesOrder table:

```
CREATE TABLE SalesOrder (
ord_id  NUMBER(10),
ord_date DATE,
cust_id NUMBER(10),
emp_id NUMBER(10));
```

```
INSERT INTO SalesOrder VALUES
      (100,'5-Sep-05', 1, '1000');
INSERT INTO salesOrder VALUES
      (101, '1-Sep-05', 1, '1000');
```

The following statements show how to create an object view on the top of the SalesOrder relational table:

```
CREATE TYPE SalesOrder_type AS OBJECT(
sales_ord_id    NUMBER(10),
        ord_date DATE,
        cust_id NUMBER(10),
        emp_id NUMBER(10));

CREATE VIEW customer_order_view OF
SalesOrder_type WITH OBJECT IDENTIFIER
(sales_ord_id)
AS SELECT o.ord_id, o.ord_date, o.cust_id,
o.emp_id
        FROM salesOrder o
          WHERE o.cust_id = 1;
```

The following SQL statement generates the view output:

```
SELECT * FROM customer_order_view;
```

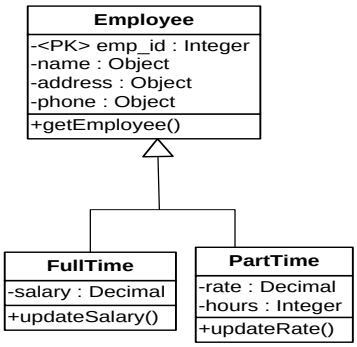
SALES_ORD_ID	ORD_DATE	CUST_ID	EMP_ID
100	05-SEP-05	1	1000
101	01-SEP-05	1	1000

The object view is a bridge that can be used to create object-oriented applications without modifying existing relational database schemas. By calling object views, relational data can be retrieved, updated, inserted, and deleted as if such data were stored as objects. The following statement can retrieve Analysts as object data from the relational SalesOrder table. Using object views to group logically-related data can lead to better database performance.

5.2 Inheritance for Object Reuse

The main advantages of extending the relational data model come from reuse and sharing. If multiple applications use the same set of database objects, then you have created a de facto standard for the database objects, and these objects can be extended (Price, 2002). ORDBMSs allow users to define hierarchies of data types. With this feature, users can build subtypes in hierarchies of database types. If users create standard data types to use for all employees, then all of the employees in the database will use the same internal format.

Users might want to define a full time employee object type and have that type inherit existing attributes from employee_ty. The full_time_ty type can extend employee_ty with attributes to store the full time employee's salary. The part_time_ty type can extend employee_ty with attributes to store the part-time employee's hourly rates and wages. Inheritance allows for the reuse of the employee_ty object data type. The details are illustrated in the following class diagram:



Object type inheritance is one of new features of Oracle 9i. For employee_ty to be inherited from, it must be defined using the NOT FINAL clause because the default is FINAL, meaning that object type cannot be inherited. Oracle 9i can also mark an object type as NOT INSTANTIABLE; this prevents objects of that type derived. Users can mark an object type as NOT INSTANTIABLE when they use the type only as part of another type or as a super_type with NOT FINAL. The following example marks address type as NOT INSTANTIABLE:

```
CREATE TYPE employee_ty AS OBJECT (
  emp_id       NUMBER,
  SSN          NUMBER,
  name         name_ty,
    dob            DATE,
  phone          varray_phone_ty,
  address        address_ty
) NOT FINAL NOT INSTANTIABLE;
```

To define a new subtype full_time_ty inheriting attributes and methods from existing types, users need to use the UNDER clause. Users can then use full_time_ty to define column objects or table objects. For example, the following statement creates an object table named FullTimeEmp.

```
CREATE TYPE full_time_ty UNDER employee_ty (
Salary  NUMBER(8,2));

CREATE TABLE FullTimeEmp of full_time_ty;
```

The preceding statement creates full_time_typ as a subtype of employee_typ. As a subtype of employee_ty, full_time_ty inherits all the attributes declared in employee_ty and any methods declared in employee_ty. The statement that defines full_time_ty specializes employee_ty by adding a new attribute "salary". New attributes declared in a subtype must have names that are different from the names of any attributes or methods declared in any of its supertypes, higher up in its type hierarchy. The following example inserts row into the FullTimeEmp table. Notice that the additional salary attribute is supplied

```
INSERT INTO FullTimeEmp VALUES
(1000, 123456789, name_ty('Jim',  'Fox', 'K'),
'12-MAY-1960',
varray_phone_ty('(626)123-5678',  '(323)343-
2983', '(626)789-1234'),
Address_ty ('3 Lost Spring Way', 'Orlando', 'FL',
32145), 45000.00);

SELECT * FROM FullTimeEmp;
```

EMP_ID	SSN	NAME(F_NAME, L_NAME, INITIALS)	DOB	PHONE	ADDRESS(STREET, CITY, STATE, ZIP)	SALARY
1001	123456789	NAME_TY('Jim', 'Fox', 'K')	12-MAY-60	VARRAY_PHONE_TY('(626)123-5678', '(323)343-2983', '(626)789-1234')	ADDRESS_TY('3 Spring Way', 'Orlando', 'FL', 32145)	45000

A supertype can have multiple child subtypes called siblings, and these can also have subtypes. The following statement creates another subtype part_time_ty under Employee_ty.

```
CREATE OR REPLACE TYPE part_time_ty UNDER
employee_ty (
rate Number(7,2),
hours Number(3))NOT FINAL;

CREATE TABLE PartTimeEmp of part_time_ty;
```

A subtype can be defined under another subtype. Again, the new subtype inherits all the 87attributes and methods that its parent type has, both declared and inherited. For example, the following statement defines a new subtype

student_part_time _ty under part_time_ty. The new subtype inherits all the attributes and methods of student_part_time _ty and adds two attributes.

CREATE TYPE student_part_time_ty UNDER part_time_ty
(school VARCHAR2(20),
year VARCHAR2(10));

5.3 Object Integration with Interface

ORDBMS combines attributes and methods together in the structure of object type. The object type interface includes both attributes and its methods. The public interface declares the data structure and the method header shows how to access the data. This public interface serves as an interface to applications. The private implementation fully defines the specified methods.

Public Interface

Specification:
Attribute declarations
Method specifications

Private Implementation

Body:
Method implementations

The following statement displays the public interface of the object type name_type. The output of the name_type public interface shows attributes and method headers as follows:

DESC name_ty;

Name	Type
F_NAME	VARCHAR2(25)
L_NAME	VARCHAR2(25)
INITIALS	CHAR(2)

METHOD
MEMBER FUNCTION ***FULL_NAME*** *RETURNS* ***VARCHAR2***

Although the user-defined methods are defined with object data within the object type, they can be shared and reused in multiple database application programs. This can result in improved operational efficiency for the IT department, as well, by improving communication and cooperation between applications. An object-relational database schema consists of a number of related tables that forms connected user-defined object-types. Object-types possess all the properties of a class, data abstraction, encapsulation, inheritance and polymorphism. These traits of object-types are embedded in the relational nature of the database; data model, security, concurrency, normalization. In more precise words, the underlying ORDB data model is relational because object data is stored in tables or columns.

6. LEARNING OUTCOMES

The provided ORDB script guides students with hands-on learning experience in the classroom. Once they have understood they can use the script as templates to do their homework assignments and projects. ORDB, implement it with Oracle 9i/10g, and create ORDB applications using various tools. As a result, the following learning outcomes are demonstrated at the end of the class. Students are able to:

1. Map UML class diagrams to ORDB databases
2. Use Object Types to remove transitive dependency
3. Use VARRAY types for multi-value attribute
4. Use NESTED TABLE types to Solve non-1NF problems
5. Implement inheritance with sub-object types
6. Create object views in the existing relational databases

ORDB technology helps students to better understand object-oriented principles such as encapsulation, inheritance, and reusability. During the learning process, they have reviewed the object-oriented paradigm they learned from their previous programming courses and are able to tie it to ORDBMS and object-oriented system design.

With a grasp of ORDB technology, students are able to make their database design more structured and consistent. With object reuse and standard adherence, students are able to create a de facto standard for database objects and multiple database applications. The motivation to learn in class is high because students have realized that object-relational technology is incorporated in most commercial DBMS. Learning it will help their career development in the future competitive job market.

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Appendix 1 Pacific Trader's Object-Relational Database Design