Volume 13, No. 3
May 2015
ISSN: 1545-679X

Information Systems Education Journal

In this issue:

The **Information Systems Education Journal** (ISEDJ) is a double-blind peer-reviewed academic journal published by **EDSIG**, the Education Special Interest Group of AITP, the Association of Information Technology Professionals (Chicago, Illinois). Publishing frequency is six times per year. The first year of publication is 2003.

ISEDJ is published online (http://isedjorg). Our sister publication, the Proceedings of EDSIG (http://www.edsigcon.org) features all papers, panels, workshops, and presentations from the conference.

The journal acceptance review process involves a minimum of three double-blind peer reviews, where both the reviewer is not aware of the identities of the authors and the authors are not aware of the identities of the reviewers. The initial reviews happen before the conference. At that point papers are divided into award papers (top 15%), other journal papers (top 30%), unsettled papers, and non-journal papers. The unsettled papers are subjected to a second round of blind peer review to establish whether they will be accepted to the journal or not. Those papers that are deemed of sufficient quality are accepted for publication in the ISEDJ journal. Currently the target acceptance rate for the journal is under 40%.

Information Systems Education Journal is pleased to be listed in the 1st Edition of Cabell's Directory of Publishing Opportunities in Educational Technology and Library Science, in both the electronic and printed editions. Questions should be addressed to the editor at editor@isedj.org or the publisher at publisher@isedj.org.

INFORMATION SYSTEMS EDUCATION JOURNAL

Student Engagement: The core model and inter-cohort analysis

Christopher J. Davis
davisc@usfsp.edu

Karla Kmetz
kmetz1@usfsp.edu

University of South Florida Saint Petersburg
Saint Petersburg, FL 33703-5016

Abstract

Prior research in higher education shows that engagement has been inconsistently conceptualized: semantic inconsistency has been compounded by variations in the constructs used to operationalize engagement. Acknowledging these limitations, we conceptualize student engagement as a multi-faceted meta-construct, overcoming some of the limitations evident in prior studies. This supports a research design that enables us to tap the capacity of the LMS at our institution to operationalize the constructs that undergird the Bundrick et al (2014) model. Our inter-cohort analysis reveals significant variations in individuals' engagement with the on-line course. Our findings suggest that interactions among the primary elements of the learning environment—the student, the teacher, and the content—significantly affect engagement and student outcomes. Our findings also suggest an urgent need to deepen investigation of student engagement to more fully investigate the dynamics of interaction as on-line learning environments account for an increasing proportion of higher education.

Keywords: online learning, engagement, interaction, information systems, analytics

1. INTRODUCTION

Quality Matters Standard 5, Learning Interaction and Engagement, is based on research on best practices for online course design. Each of the four guidelines encompassed within this standard promote *engaging* students to become active learners, which will contribute to their learning process and their persistence (Quality Matters, 2011). These guidelines include learning activities to promote the achievement of the stated learning objectives; learning activities to provide for the interaction that support active learning, the instructors plan for response time and feedback, and explanation of requirements for student interaction.

In the wider context of higher education, engagement is seen primarily as a quality of the school or college rather than a trait of the individual. The amount of time and effort students put into their studies and other educationally purposeful activities is one of the 'critical features' of engagement used by Indiana University's National Survey of Student Engagement (NSSE) to measure collegiate quality. NSSE also assesses how the institution deploys its resources and organizes the curriculum and other learning opportunities to enable and encourage students to participate in activities that, they argue, research studies show are linked to student learning.

In this research, we revisit this linkage and explore the dynamics of participation in a little more depth. Rather than estimates of how students spend their time and what they gain from attending college – the focus of NSSE – we explore engagement at the individual student, course and instructor level. This is the locus of evolution for engagement. Summary statistics mask variations at these levels which, we argue, are critical to understanding students' learning needs and performance. In this research, we have strived to address this limitation by making the student the primary unit of analysis. This enables us to explore the interactions between the three 'core' components of learning – the instructor, the material and the student. Both our course design and our research design emphasize the need for effective scheduling and 'choreography' of these core components.

The assignment schedule for the course is one of the content elements developed with this need in mind: it also follows best practices for interaction and thus aligns with Standard 5 of the Quality Matters rubric. The rubric outlines three types of interaction to promote student success within an online course: student-student interaction, student-content interaction, and student-teacher interaction. With the implementation of these best practices for student interaction and engagement in place within the course, it seems reasonable to expect that students should perform well academically if they complete the course assessment schedule. This paper will test this expectation using empirical data to compare student engagement and academic achievement in a Systems Analysis and Design course over two semesters.

2. PRIOR RESEARCH

Prior research in higher education shows that *engagement* has been inconsistently conceptualized (Appleton, Christenson, & Furlong, 2008; Fredricks & McColsky, 2012). Behavioral and psychological indicators (e.g., Finn, 1989; Newmann, 1992) have been used in various combinations, giving rise to inconsistent terminology (Bundrick et al, 2014). Terms such as *school engagement* (e.g., Fredricks, Blumenfeld, & Paris, 2004), *student engagement* (Willms, 2003) and *academic engagement* (Libbey, 2004) have been used interchangeably. This semantic inconsistency has been compounded by variations in the constructs used to operationalize engagement. Acknowledging these limitations, we conceptualize *student engagement* as a multi-faceted meta-construct that accommodates important distinctions among students' evaluations and experiences in the various conceptually distinct dimensions of their learning environment: behavioral, cognitive, and emotional.

Bundrick et al (2014) articulate these distinctions: *Behavioral engagement* refers to various behaviors that are directly oriented to learning, such as attending and contributing to classes, compliance with rules, completing assignments and the time and effort put into studying. *Cognitive engagement* is a little less tangible since it involves the student's psychological 'investment' in learning and mastery of academic materials and their desire for challenge. Cognitive engagement is manifest in metacognitive strategies such as planning, monitoring, and evaluating one's thinking; and self-regulation. *Emotional engagement* refers to students' feelings about their relationships with others in the learning environment (e.g., teachers, peers) and the general sense of belonging and connectedness that is often derived from such relationships: these inform student perceptions of self-efficacy (Compeau et al, 1995, 1999) and confidence regarding their academic ability.

Prior research on effective student interaction and engagement provides the basis for implementation of our course design objectives. Student-student interaction, often implemented through discussion boards, has been found to increase student satisfaction in a course (Rothmund, 2008). Additionally, social interaction has been found to play a significant role in students' sense of learning (Hill et al., 2009). Davies and Graff (2005) found that the level of participation in online discussion boards did not correlate with overall course performance; however, Rovai and Barnum (2003) found that active interaction, the number of messages posted by students per week, was a significant predictor of perceived learning. Nussbaum et al (2004) found that the quality of interactions could play an important role in student outcomes. Therefore, a set of criteria demanding high quality participation, such as including sources and providing examples in discussion responses, could provide a meaningful level of engagement to act as a predictor of student success. Sher (2009) found that both student-student interaction and student-instructor interaction were significant contributors to student learning and satisfaction.

Prior research on the effectiveness of student interaction and engagement in online courses has focused primarily on measuring success through student perceptions and student satisfaction. However, as Bundrick et al (2014) have shown, research into engagement among students in higher education has been distorted through over-abstraction – the assumption that summary statistics have a generalizable validity to whole populations.

We address this shortcoming by focusing attention on more fundamental measures of personal interaction within the core learning components. We aim to develop a more causally robust linkage between engagement and performance and, in so doing, propose indicators of engagement that are more immediately relevant to students, instructors and course designers in the rapidly evolving milieu of on-line core learning components.

3. RESEARCH SETTING

The University of South Florida St. Petersburg (USFSP) offers a range of distinctive graduate and undergraduate programs in the arts and sciences, business, and education within a close-knit, student-centered learning community that welcomes individuals from the region, state, nation and world. We conduct wide-ranging, collaborative research to meet society's needs and engage in service projects and partnerships to enhance the university and community's social, economic and intellectual life. As an integral and complementary part of a multi-institutional system, USF St. Petersburg retains a separate identity and mission while contributing to and benefiting from the associations, cooperation, and shared resources of a premier national research university. The university's online learning is delivered through a learning management system; Canvas by Instructure.

The recent adoption of Quality Matters (Quality Matters, 2013), an online course quality management program, at USFSP has provided a set of specific standards that can be used to enhance the accessibility of courses. Quality Matters is a quality assurance program that facilitates a peer review process to recognize courses that follow best practices for design and promote student success in online education. Courses are reviewed using a rubric (Quality Matters, 2011) comprising a set of eight research-based standards for design that heavily promote student engagement.

4. RESEARCH DESIGN

The review above prompts us to posit that students who display higher levels of engagement perform academically at a higher level than those who display lower levels of engagement. In this initial research, we explored this relationship using a robust but rather rudimentary analysis which enabled us to directly compare two cohorts of students in the Systems Analysis and Design course.

The complexity and conceptual richness of the design artifacts and process taught and assessed in the Systems Analysis and Design course provides a broad and diverse range of opportunities for engagement (Avison and Fitzgerald, 2006; Topi et al, 2010). The learning outcomes are both a prerequisite for and a predictor of success in the major (Kmetz & Davis, 2014): they have also been aligned with the skills indicative of mastery of the language, tools and techniques that enable their effective use in employment (Yourdon, 1993; Topi et al, 2010).

Professional as well as instructional experience in this highly applied field highlights engagement as a 'critical success factor' for the synthesis of the technical skills and cognate knowledge. Although by no means unique, the interdependence of these learning outcomes and the core learning components on which they depend place students who disengage at substantially higher risk of failure than those pursuing more didactic courses.

Bundrick et al (2014) consider how the primary elements of the learning environment—the student, the teacher, and the content—interact to affect engagement, and propose a conceptual model that highlights the interdependence of these core elements and interactions.

Our research design operationalizes this model: however, our units of analysis are rather coarse, limited by the range of metrics provided by the LMS. Following Bundrick et al (2014) we identified a number of surrogate metrics to operationalize the constructs underlying engagement: data for the analysis was drawn directly but anonymously from the course analytics provided by the LMS. These include page views, participations, and assignment submissions.

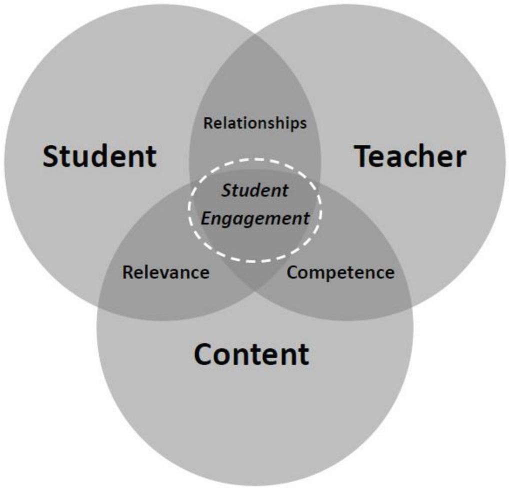


Figure 1 The Student Engagement Core Model (Bundrick et al, 2014)

Page views are calculated for each student from the day that the course opens to the day that the course closes. Canvas records a page view anytime a student lands on a page within the course. Course pages include Home, Syllabus, module instruction pages, and assignment instruction pages.

In addition to page views, Canvas analytics calculates cumulative participation counts for each student. A participation is recorded any time a student submits a quiz, starts taking a quiz, submits an assignment, creates a wiki page, posts a new comment to a discussion, joins a web conference, or loads a collaboration to view or edit the document.

The analytics also provides an overview of the student's assignment submissions over the semester. It provides a count of the on-time submissions, late submissions, and missing submissions.

The first section of this course was offered during a six-week session during Summer 2013. The second section of was offered during a full-length semester in Fall of 2013. Both sessions were offered completely online and shared a common teaching and assessment model comprising 24 assignments.

Figure 2 Example view of student analytics.

The assessment regime is comprehensive, designed using the pedagogic and evaluative guidance provided by Topi et al (2010). The synthesis of cognate, analytic and design competence responds both to this curricular guidance and the trends through industry and employment analyses (Avison et al, 2006).

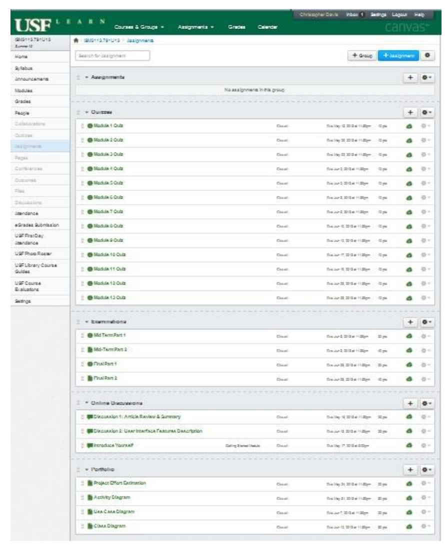


Figure 3 Assessment 'regime' (see also Appendix A)

Opportunities for engagement in this course are designed to promote student-student, student-content, and student-instructor interaction. The assessment schedule includes a discussion board to allow students to introduce themselves and meet their classmates. This creates a community of learning within the course. Each of the 13 learning modules includes a low-stakes quiz that acts as a knowledge check for the students. To assess students' comprehension and application of the material there are two discussion boards centered around important topics in the field and four portfolio assignments allowing students to demonstrate their ability to complete major tasks within a systems analysis and design project. The summative assessment for this course includes two exams; a midterm and final. Both exams consist of two parts; a multiple choice portion and an essay portion. Each module also includes lectures, examples, and readings.

5. FINDINGS

The Summer 2013 Section was completed by 34 students: the table below summarizes the surrogate metrics that we used to assess their levels of engagement and the resultant leaning outcomes. The table sets the data out in broad grade-based classes (rows) to maintain cohesion in our commentary, providing consistency with the performance and outcome metrics used in the research reported in Section 2. This also provides a familiar basis for comparison with grading schema used to report learning outcomes at other institutions.

Final Grade Range	Average Page Views Per Student	Average Participations Per Student	Average Assignments submitted on time per student	Average assignments submitted late per student	Average assignments missing per student
90% - 100% (6 students)	548.00	35.30	23.80	0.20	0.00
80% - 89% (25 students)	601.80	32.90	23.10	0.10	0.80
70% - 79% (3 students)	713.70	26.30	20.30	1.70	2.00
Below 70% (0 students)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

Table 1 Summer 2013 Engagement and Outcomes

Table 1 shows the relationship between participation and outcome: note that no students were assessed at below 70% in this cohort. The cohort size in this short six-week 'semester' was reduced significantly (from an initial 40 students) immediately prior to the 'drop' date. The dynamics of the relationship between students' anticipation of success or other 'outcome' is not clear. However, it seems reasonable to infer that those in this cohort with failing grades chose not to continue. The brevity of the semester gave students an opportunity to drop the class without academic penalty just a few days before its end: this skews the sample significantly.

Such discontinuance clearly affects the grade distribution. Recent work by Munro (2014) highlights other significant characteristics of such disengagement: often condoned by instructors, it gives rise to grade inflation and, he argues, is a form of fraud.

Nevertheless, Figure 4 provides insight into the relationship between outcomes and engagement as measured through participation in the assessment 'regime' set out in Figure 3. To provide a benchmark to interpret these data, it should be noted that there are 24 assessments that students participate in: of those, 18 provide one opportunity to participate (the quizzes and modeling submissions that build the student portfolio). The discussions, on the other hand, are more interactive. The two graded discussions require multiple participations: the first to 'post' and 'reply'; the second to 'post' and then reply to each of two 'threads'. In combination, the 24 participations span a range of interactions and thus provide the multi-faceted indication of engagement that Bundrick et al (2014) propose.

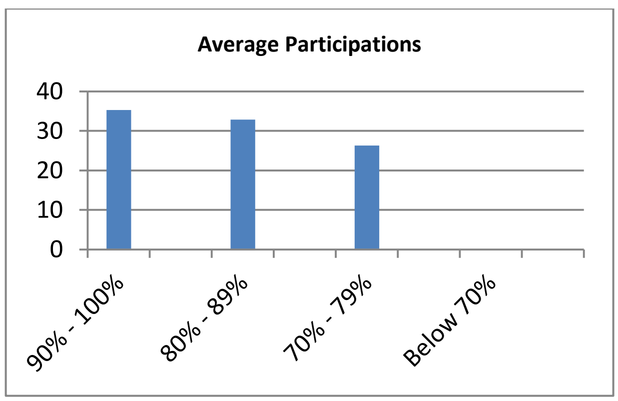


Figure 4 Summer 2013 Participation

A differently nuanced indicator of engagement is provided through measurement of the number of page views. Although less substantive than measures of participation - since they do not discriminate between mere browsing and more intellectually engaged reading and assimilation -

their overall volume provides a complementary scale and arguably more normalized measure of engagement.

Overall, students in this cohort engaged with the material 621 times or about 15 times per day during the 6 week duration of the course. Figure 5 shows that the standard deviation in this much larger data sample is quite low: the difference between the highest and lowest columns is only 166.

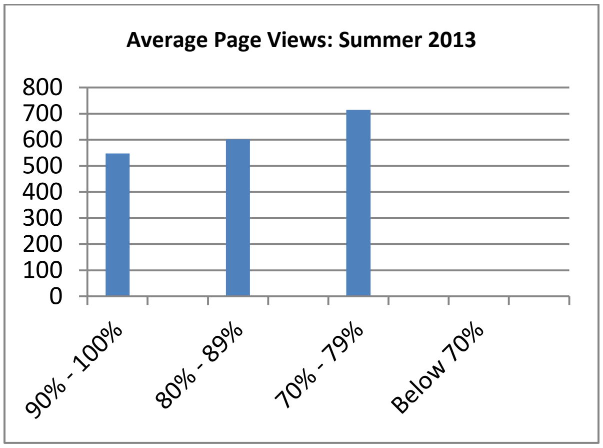


Figure 5 Summer 2013 Page views

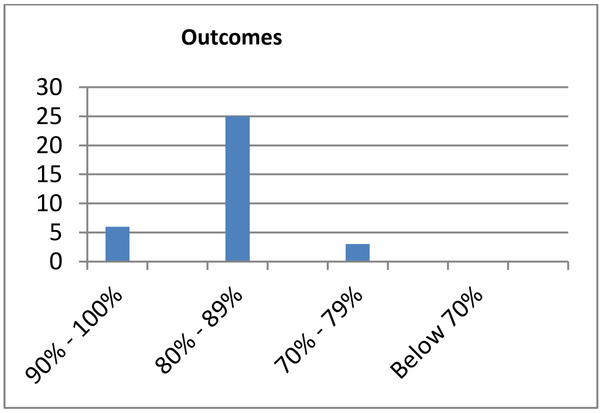


Figure 6 Summer 2013 Outcomes

Two observations can be made here: firstly, classification of the data using outcomes masks internal variations. Our observations while the course was live showed significant variations within each of the broad categories in Figure 4. Our current research strives to make these episodic variations more tractable. Secondly, the trend of the data seems counterintuitive: the relationship between number of page views and quality of outcome as indicated by the grade received is inverse. In the context of engagement, this seems significant, suggesting that participation is a more reliable indicator of outcome than page views.

We turn now to consider two more assessment indicators of engagement. Figure 7 shows the average counts for timely submission of the twenty four assignments (see Figure 3). Here, a more direct relationship is immediately clear: timely submission of assignments correlates positively with outcomes.

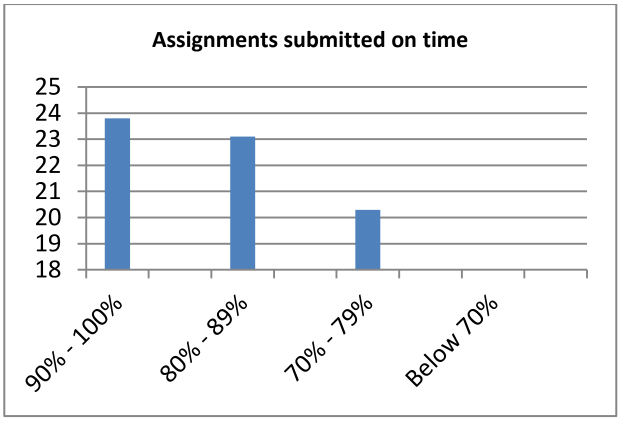


Figure 7 Summer 2013 Assignment timeliness

As might be anticipated, late submission of assignments correlates negatively with outcomes. Although significantly smaller, this data set shows remarkable symmetric consistency with those in Figure 8.

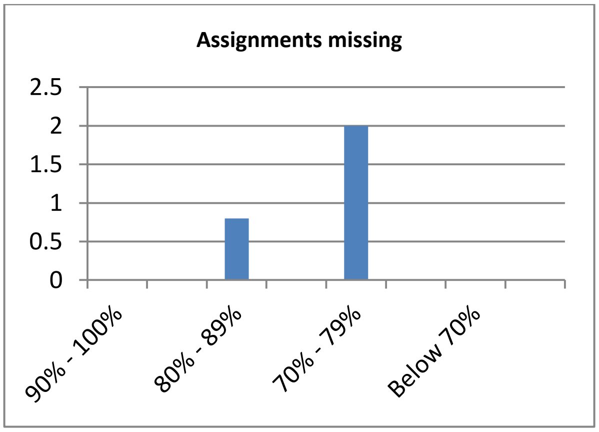


Figure 8 Summer 2013 Assignment completeness

Considering Figures 5, 6, 7 and 8 together, the data present apparently contradictory relationships between the level of engagement with the materials overall and outcomes (compare Figures 5 and 6) and that between engagement with the assignments (compare Figures 6, 7 and 8).

The metrics for Fall 2013 are summarized in Table 2: they show the engagement and outcomes for the (larger) 41 student cohort and allow us to explore this apparent contradiction a little further.

Final Grade Range	Average Page Views Per Student	Average Participations Per Student	Average Assignments submitted on time per student	Average assignments submitted late per student	Average assignments missing per student
90% - 100% (4 students)	811.50	49.00	24.00	0.00	0.00
80% - 89% (24 students)	611.30	42.40	23.40	0.60	0.00
70% - 79% (8 students)	483.00	36.10	23.10	0.30	0.60
Below 70% (5 students)	283.40	13.40	7.20	1.00	15.80

Table 2 Fall 2013 Engagement and Outcomes

The cohort size in this full semester was more stable than Summer 2013, although large for such a technical course.

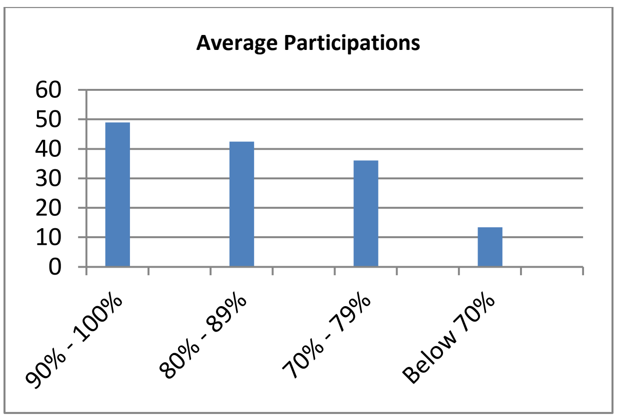


Figure 9 Fall 2013 Participation

Figure 9 shows a strong correlation between outcomes and engagement as measured through participation in the assessment 'regime' set out in Figure 3. Participation rates are high: an average of 49 participations for students in the top performance category.

Students in the lowest category show substantially lower engagement, participating on average only 27% of the level of those achieving the highest grade outcome.

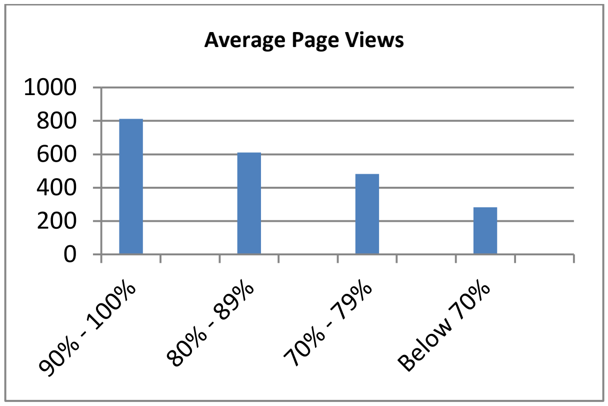


Figure 10 Fall 2013 Page views

Overall, students in this cohort engaged with the material 547 times. This represents a lower 'density' of engagement in this longer 15 week semester at only 5 views per day. This is consistent with the number of student 'effort hours' expected at this institution: 5 views per day when 10 hours of effort per week are expected equates to about 12.5 views per day in a six-week semester – such as the one analyzed above - where 25 hours effort per week are anticipated.

Figure 10 also reveals a higher standard deviation for the longer course: the difference between the highest and lowest columns is significant at 527. On average, higher performing students viewed the course content three times more frequently than those in the lowest category.

Again it should be remembered that our classification of data using outcomes masks internal variations. Our observations while the course was live showed similar significant variations *within* each of the broad categories in Figure 10. The highest and lowest number of views for the highest outcome class was 1102 and 585: the low is less than half of the high.

For those who achieved a B (80-89%) the figures were 996 and 339: the low is a little over one third of the high. This is consistent with the size of this group (24) in our outcome distribution. Those who achieved a C (70-79%) ranged from 754 to 476 page views: a much narrower range – again a function of the group size (8 students).

The lowest performing group included two students who did not complete the course. The range is large here: from 669 to 40 page views. Nevertheless, the overall trend of the data for the Fall 2013 cohort seems more intuitive: the correlation between number of page views and outcome is positive.

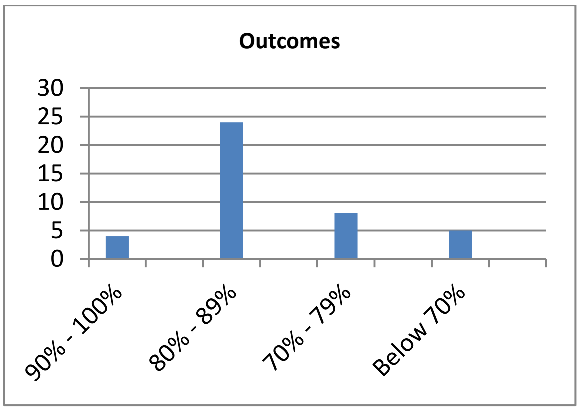


Figure 11 Fall 2013 Outcomes

Turning to our assignment-oriented indicators of engagement, we see that Figure 12 reveals a similarly direct correlation between submission timeliness for the twenty four assignments (see Figure 3) and outcomes.

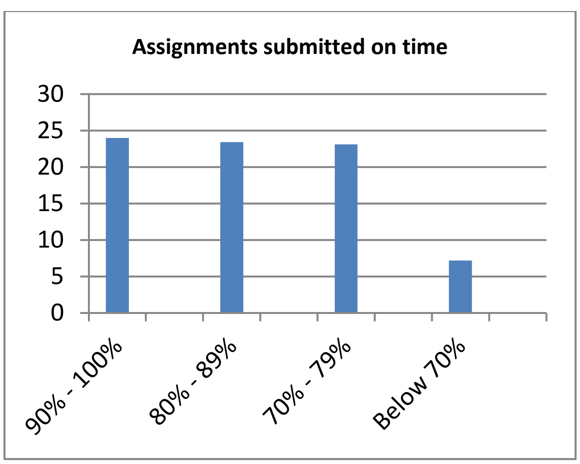


Figure 12 Fall 2013 Assignment Submission

Again we see some intuitive complementarity in the distributions of assignments submitted on time and those missing completely. However, comparison of Figures 12 and 13 shows a stronger 'fall off' between those achieving passing grades and those who didn't.

The apparent contradiction seen when Figures 5, 6, 7 and 8 (for the Summer cohort) are considered together is not evident when Figures 10-13 are compared. For the Fall 2013 cohort the relationships between the level of engagement with the materials overall and outcomes (Compare Figures 9 and 11) are more consistent with that for engagement with the assignments (Compare Figures 11, 12 and 13).

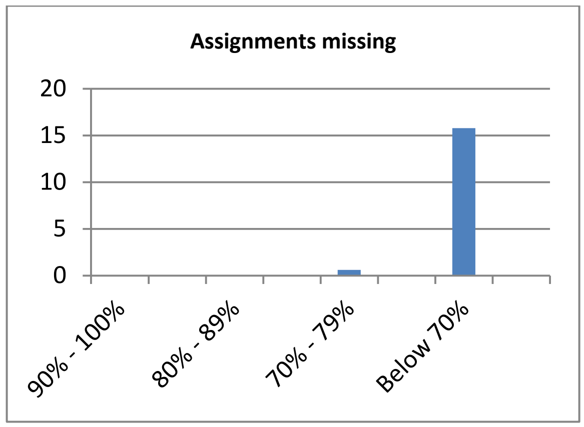


Figure 13 Missing Assignments Fall 2013

6. COMMENTARY

Our analysis uses metrics that measure some of the interactions in the Bundrick et al (2014) Student Engagement Core Model (Figure 1). Despite the limitations that we discuss below, the data provide coherent and consistent comparisons of student engagement. The overall similarity between the data sets for the two cohorts highlights this. It also highlights the significant difference in the patterns of engagement between the two cohorts as measured by page views.

Figure 14 shows opposing trends in the relation between page views and outcome. The blue bars show engagement for the Summer cohort. The correlation between page views and outcomes is negative. These summary data again disguise intra-class variation.

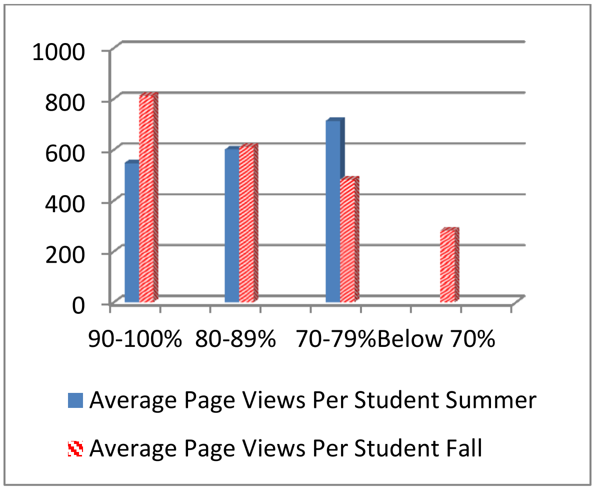


Figure 14 Engagement and Outcomes: two semester comparison

The highest and lowest number of views for the highest outcome class was 1003 and 366. Here, the low is close to one third of the high, a significantly larger proportion than that seen among the equivalent group in the fall cohort. For those who achieved a B (80-89%) the figures were 951 and 292: here the low is less than one third of the high (31%). This is consistent with both the size of this group (25 students) in the outcome distribution and – perhaps significantly – the range in the higher performing group. Those in the Summer cohort who achieved a C (70-79%) ranged from 952 to 590 page views: two observations are pertinent here. Firstly, the range among the students (n=3) in this group is narrow, the low being almost two thirds (62%) of the high. Secondly – and perhaps consequently – the average for this group is closer to that for the other two outcome groups in this cohort. This gives a much lower gradient to the trend in Figures 5 and 14.

The trend for the Fall 2013 cohort (Figure 10 and the red bars in Figure 14) has an inverse gradient but one which – more intuitively – indicates that performance decreases as page views decrease.

Page views among students in the 80-89% outcome class are remarkably similar, both in number and range. For the Summer cohort, the low of 292 is 31% of the high (951). For the Fall cohort, the low is 34% (339) of the high (996).

Although the data for this inter-cohort comparison do not immediately reveal a causal link between page views and outcomes, the inconsistencies are significant and raise a number of questions. Although, on the face of it, it might be argued that participations and assignment submission figures provide more reliable prediction of outcomes, this deflects from the potential that these finer-grained data contribute to our understanding of the dynamics of student engagement.

7. CONCLUSIONS

In this work we have strived to overcome some of the limitations evident in prior studies of student engagement. By conceptualizing engagement as a multi-faceted meta-construct we developed a research design that enabled us to explore the capacity of the LMS at our institution to operationalize the constructs that undergird the Bundrick et al (2014) model.

Clearly, our study is limited by a number of factors: the single course comparison and the 'coarseness' of the data provided by the LMS, both in terms of the range of scales measures and the limited number of time-points at which they are reported.

Nevertheless, this initial research highlights the potential of the cohort and individual (student) units of analysis to provide insights into engagement that substantially supplement the collective institution-level analyses presented by NSSE.

Although 'complete', this research presents more questions than answers: we are currently working with our LMS providers and administrators to extract data that will provide an even more dynamic view of the interactions at the heart of the Bundrick et al (2014) model (Figure 1 above). This will enable our future work to address the limitations set out above and the questions posed. In particular, we will use the more comprehensive data to relate student interactions, engagement and outcomes in the on-line 'classroom' setting to examine the level and significance of inter-student engagements noted by Baepler & Walker (2014). The research question here is whether participation in collaborative assignments such as those designed for the course discussed in this paper allow more full 'exploitation' of the opportunities that 'new classrooms' present and thus positively affect student outcomes.

8. REFERENCES

Baepler, P., & Walker, J. D. (2014). Active Learning Classrooms and Educational Alliances: Changing Relationships to Improve Learning. *New Directions For Teaching & Learning*, *2014*(137), 27-40. doi:10.1002/tl.20083

Bundrick, M; Quaglia, R; Corso, M. and Haywood, D. (2014) Promoting Student Engagement in the Classroom. *Teachers College Record* Volume 116, 1-34.

Compeau, D. and Higgins, C. (1995) "Computer self-efficacy: Development of a measure and initial test." *MIS Quarterly* 19(2).

Compeau, D: Higgins, C and Huff, S. (1999) "Social cognitive theory and individual reactions to computing technology: A longitudinal study." *MIS Quarterly* 23(2), 145-158.

Davies, J., & Graff, M. (2005). Performance in e-learning: Online participation and student grades. British Journal of Educational Technology, 36(4), 657-663.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*, 59–109.

Hill, J., Song, L., & West, R. (2009). Social learning theory and web-based learning environments: A review of research and discussion of implications. *The American Journal of Distance Education*, 23(2), 88.

Kmetz, K. & Davis, C. (2014) Access to On-line Learning: A SAD Case. *Information Systems Education Journal*, 12(2) 10-17

Libbey, H. P. (2004). Measuring student relationship to school: Attachment, bonding, connectedness, and engagement. *Journal of School Health, 74*, 274–283.

Nussbaum, E. M., Hartley, K., Sinatra, G. M., Reynolds, R. E., & Bendixen, L. D. (2004). Personality interactions and scaffolding in online discussions. *Educational Computing Research*, 30(1&2), 113-137.

Quality Matters. (2013). *Quality matters: higher education program*. Retrieved from https://www.qualitymatters.org/higher-education-program

Quality Matters (2011). Quality matters: higher education rubric. Retrieved June 6 2014 from https://www.qualitymatters.org/user?destination=/layout1/download/QM520Standards5202011-2013-4.pdf

Rothmund, C. (2008). Correlation between course interactivity and reported levels of student satisfaction in hybrid courses. (Capella University). ProQuest Dissertation and Theses, Document ID 30481888.

Rovai, A. O. & Barnumm K. T. (2003). On-line course effectiveness: an analysis of student interactions and perceptions of learning. *Journal of Distance Education*, 18(1), 57-73.

Sher, A. (2009). Assessing the relationship of student-instructor and student-student interaction to the student learning and satisfaction in web-based online learning environments. *Journal of Interactive Online Learning*, 8(2).

Willms, J. D. (2003). Student engagement at school: A sense of belonging and participation. Paris, France: Organisation for Economic Co-Operation and Development.

Editor's Note:

This paper was selected for inclusion in the journal as an ISECON 2014 Distinguished Paper. The acceptance rate is typically 7% 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 2014.

Appendix A

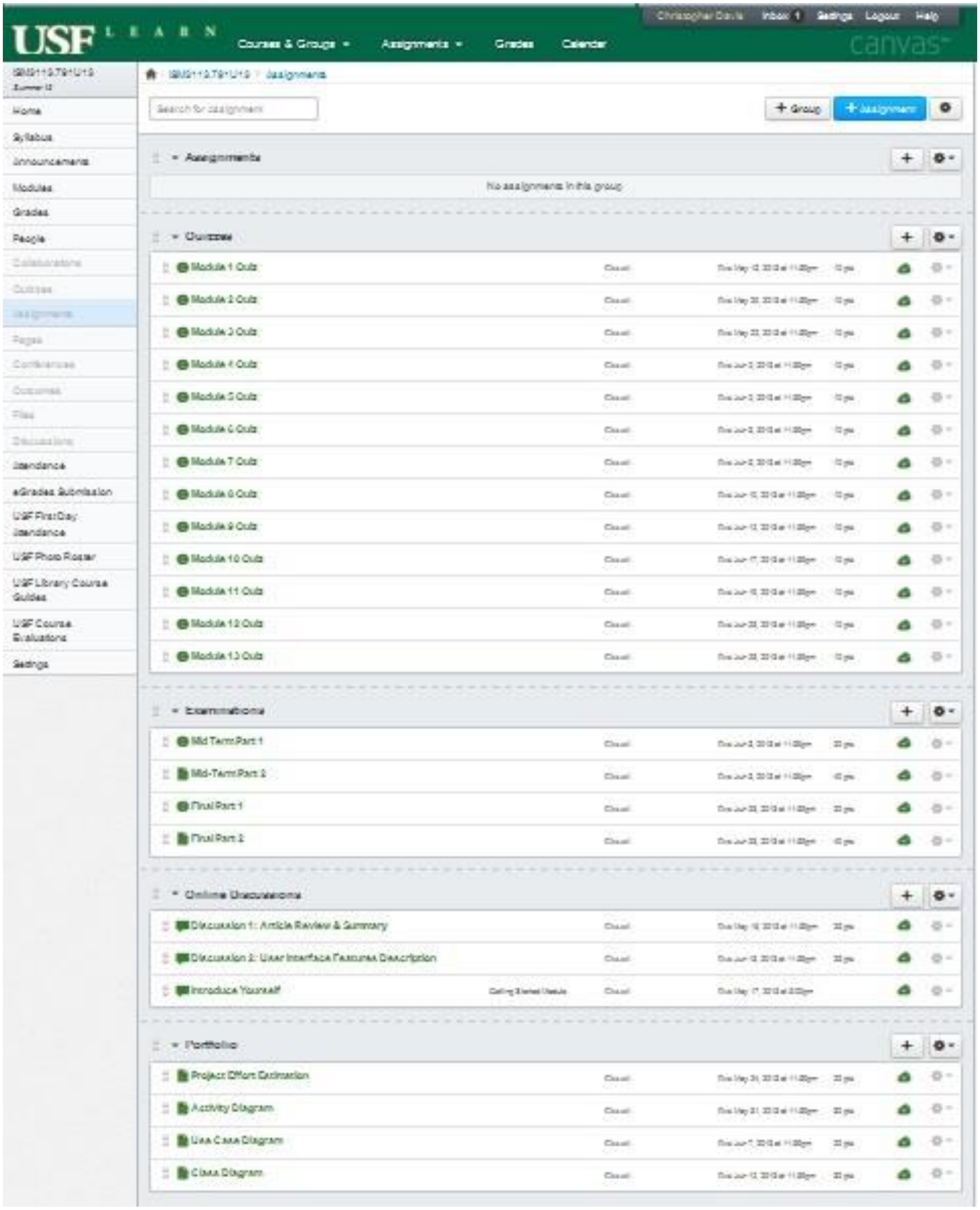


Figure 3 **Assessment Regime**

The Impact of Programming Experience on Successfully Learning Systems Analysis and Design

Wang-chan Wong
wcwong@csudh.edu
Information Systems and Operations Management Department
California State University
Dominguez Hills
Carson, CA 90747, U.S.A.

Abstract

In this paper, the author reports the results of an empirical study on the relationship between a student's programming experience and their success in a traditional Systems Analysis and Design (SA&D) class where technical skills such as dataflow analysis and entity relationship data modeling are covered. While it is possible to teach these technical skills to students without programming experience, the results of the study strongly suggest that students with programming experience complete the course more successfully than those without.

Keywords: Systems Analysis and Design, Programming, IS Curriculum, Problem Solving

1. INTRODUCTION

For many of us formally trained in Systems Analysis and Design (SA&D), it is a logical assumption that some programming experience is a pre-requisite for taking a course in SA&D. However, as we have observed, many IS departments have relaxed their programming pre-requisite requirements, and this de-emphasis is reflected in the 2010 IS curriculum (Topi, et al, 2010). Thus, this current trend prompts the question: Does the lack of a programming background hinder understanding and subsequent success? To answer this, from 2007 to 2013 the author collected the homework scores of 15 SA&D classes from a total of 259 students. Statistical analysis of the data strongly supports the notion that programming experience is important for students to successfully complete the course. There have been similar studies conducted before, but they were typically carried out in a single class with limited sample size and for a short period of time. With a large sample size spanning six years, this study is more definitive and conclusive.

The rest of the paper is organized as follows. Section 2 is a literature review of teaching SA&D, particularly regarding its relationship to programming. Section 3 discusses the background of the study, while the methodology of the empirical study is explained in Section 4. The data analysis results are presented in Section 5. Finally, concluding remarks are given in Section 6.

2. LITERATURE REVIEW

There is a significant gap between teaching and research in SA&D (Bajaj, et al, 2005). This situation is reflected by the low number of research publications in this area. It is particularly true in finding research reports on teaching SA&D.

What do experts and scholars say regarding the relationship between programming and learning SA&D? Most acknowledge that programming is an essential foundation of SA&D. Yourdon and Constantine's book on Structured Design, a classic in structured analysis and design, discusses this relationship in the foreword: "…we assume that the reader knows how to code, and is capable of writing "good code"..." (Yourdon and Constantine, 1978, page xvi)

Booch suggests that his object-oriented method is "… most appropriate for courses in software engineering and advanced programming, and as a supplement to courses involving specific object-oriented programming languages" (Booch, 1994, page viii).

Rumbaugh, et al. propose Object Modeling Technique (OMT) as a method to develop object-oriented systems and to support object-oriented programming. They suggest that pre-requisites include "exposure to modern structured programming languages and a knowledge of basic computer science terms and concepts" (Rumbaugh et al., 1991, page x).

Booth's discussion of "folk pedagogies" in software engineering asserts that students should take a programming course before a design course (Booth 2001).

Similarly, in his study on integrating programming and system analysis, Guthrie concludes that programming is the chicken, and system design is the egg. He demonstrates that a student's design skill is directly related to their programming skill (Guthrie, 2004).

Studies have been conducted to determine the actual effect of a student's prior background on their design proficiency. Judith Sims-Knight conducted a small empirical experiment in which she taught high school students and computer science students object-oriented design without programming by using CRC cards. While she found that the high school students were able to adequately handle the design process (the study did not screen whether the students had programming exposure or not), they concluded that the computer science students created more complete designs and demonstrated a deeper understanding of the design process (Sims-Knight and Upchurch, 1993).

In an experiment teaching object-oriented analysis and design (OOAD) to both computer science and math students, Boberic-Krsticev et al. (2013) note that the math students had basic problems mastering the materials, such as having difficulty acquiring fundamental concepts, and even the UML terminology. The deficiency has been attributed to the fact that these students did not have object-oriented programming backgrounds. Even with the computer science students experienced in object-oriented programming, they observe that students created UML diagrams simply for the sake of modeling; both groups of students failed to make connections between the models and their implementations. Similar to Guthrie (2004), the authors recommend that teachers should illustrate implementation in an OO programming language so students may see the connection between models and their implementations.

Chen suggests that DFDs and ERDs are the most important skills an analyst can have (Chen 2006). Only students with programming backgrounds can have a greater appreciation for the design principles that enable them to analyze and design more complex systems.

Serva (1998) argues that the technical tasks in SA&D are comparable to the difficulties of managing a project to its completion. He offers SA&D classes for non-IS students, but the coverage of the course is to simulate the difficulties of management within an IS environment and not to teach formal systems analysis and design.

Ultimately, many IS instructors, professionals, and practitioners alike prefer students to have programming experience before taking an SA&D course (Stack Overflow 2013).

3. BACKGROUND AND EMPIRICAL STUDY

The studies surveyed in Section 2 support the notion of learning programming before analysis and design. However, they are mostly small-scale experiments conducted for a short period of time. In this paper, the author is reporting on a study spanning over six years with a comfortable sample size, providing a more conclusive and definitive response to the issue.

The SA&D course in this investigation is offered by a public university -- a comprehensive urban university primarily serving a metropolitan area. Information Systems, just like other business majors such as accounting, finance, marketing, etc., is a concentration of the College of Business, instead of a single major. CIS 372 Analysis and Logical Design is a required course for IS and IS-related majors such as Information Systems Security, and Global Logistics and Supply Chain Management. However, the department has dropped the programming pre-requisite for CIS 372. The only pre-requisite of CIS 372 is CIS 370, an introductory course on Information Systems Theory and Practice. CIS 370 is also a required course for all business undergraduate students. However, it does not provide any programming training besides a few Excel and ACCESS exercises with no coding required. As it is, CIS 372 has enrolled non-IS related students ranging from general business, marketing, human resources, finance, sports, entertainment and hospitality management, international business, accounting, biology, music, criminal justice, and sociology, in addition to computer science and information systems students. In fact, none of the non-IS students in this study had any experience with programming; even though IS and IS-related students are advised to take an introductory programming class before taking CIS 372, some do not follow this advice.

4. EMPIRICAL STUDY - METHODOLOGY

Topics	Assignments*
Introduction to Analysis and Design	
Analyzing the Business Case	Analysis of a Business Case
Managing Systems Projects	Project management, Gantt Diagram in MS Project
Output and User Interface	UI Design
Requirements Modeling	Requirements Document
Data and Process Modeling	DFD diagrams in Visio and process descriptions
Data Design	ERD in Visio and data dictionary
Development Strategies	Short questions
Systems Architecture	Short questions
Managing Systems Implementation	Short questions
Managing Systems Support and Security	Short questions

*The requirements document, DFD and ERD amount to 25% of the weighted total.

Table 1: Major topics covered and student deliverables in CIS 372

CIS 372 follows the traditional Systems Analysis and Design undergraduate curriculum except that it focuses on the functional (system) approach while the object-oriented approach is covered in another course. We used *Systems Analysis & Design in a Changing World* by Satzinger, Jackson, and Burd (Satzinger et al., 2007) for several years and then changed to *Systems Analysis and Design* by Shelly and Rosenblatt (Shelly et al., 2010) in 2010. Topics and major deliverables covered in the course based on Shelly's book are shown in Table 1.

The course is not project or team-based; students work individually on homework assignments for each chapter. Since the author was interested in determining how well students without programming backgrounds can master technical skills, the homework scores of (1) the requirements document, (2) the dataflow diagram (DFD) design document, (3) the entity relationship diagram design (ERD) document, and (4) the weighted total of each student for the class were collected. The justification to select these four scores and the related hypotheses are as follows:

1. The requirements document is important in any system development, especially for non-IS students. In reality, a non-IS business person will have many opportunities to jointly develop Request for Proposals (RFP) and the requirements document with IS staff. Gaining technical writing skills will greatly improve the quality of the requirements document, RFPs, and any other project-related documentation.

2. DFD design documents are demonstrative of the technical skills that system analysts/developers need to have. These techniques train students how to capture the dynamics and behavior of a system. Needless to say, ERD is important because it trains students to capture the objects being modeled and relationships among them in the system.

3. The weighted total is the percentage of the scores a student receives. It includes all other homework assignments and exams. It is the overall measure of a student's success in this course.

In the requirements document assignment, students are asked to define both functional and non-functional requirements for certain systems. Students will generate the requirements document similar to the clausal form example as shown in (Taylor, 2013). Grading for the requirements document is based on clarity in writing, organization, and the ability to capture the major functional and non-functional requirements of the system.

For the DFD and ERD assignments, questions are typically taken from the end of chapters in the textbook. The questions are based on small-scale business scenarios that are manageable for a single student. For the DFD assignment, students are asked to draw the context diagram and then decompose it to Level 0 and/or Level 1 diagrams in Visio. Students also need to write high-level process descriptions for each primitive DFD process. Structure charts are not covered, since students without programming experience have difficulty understanding parameter passing and functional decomposition. Grading for the DFD assignment is based on the syntactic correctness of the diagrams, the appropriate logical flow to capture the dynamics and behavior of the system based on the scenario given, and the clarity of process descriptions for the primitive processes.

For the ERD assignment, students are asked to create the crow's foot model in Visio along with its data dictionary. Grading on the ERD assignment is based on how well the student identifies the entities and their relationships, including meaningful entity names, salient attributes of these entities and appropriate domain or data types for the attributes, correctness of the relationships (cardinalities) for these entities, correct primary key identification and referential integrity enforcement, and correct modeling of the logical and physical data models using Visio.

Since any student may take CIS 372 without fulfilling a programming pre-requisite, for the purposes of this study students were asked about their programming experience during the first class meeting.

Hypotheses

The requirements document is in an itemized clausal form by grouping system specifications into categories and subcategories, mirroring the hierarchical structure of a program and the relationships of its components. In an introductory programming class, students have exposure to top-down modular design, structure programming, and/or other programming paradigms such as the object-oriented approach. They are also introduced to the three basic programming constructs: sequence, iteration, and selection. In fact, if a student masters these programming fundamentals, they will easily be able to learn data flow analysis. Furthermore, in programming class, we always emphasize program documentation. When students decompose a program into sub-modules, they need to document the interface, function descriptions, in-line comments, etc. Therefore, the following two hypotheses are posited:

Hypothesis 1 (H1): A student's requirements document assignment score is positively associated with his/her programming knowledge. Students with programming backgrounds have better scores than students without programming backgrounds.

Hypothesis 2 (H2): A student's data flow assignment score is positively associated with his/her programming knowledge. Students with programming backgrounds have better scores than students without programming backgrounds.

In a typical introductory programming course, students are exposed to basic data structures such as record, array, files, and relational databases. They will have seen how records are linked and processed. Therefore, the following hypothesis is posited:

Hypothesis 3 (H3): A student's entity relationship modeling assignment score is positively associated with his/her programming knowledge. Students with programming backgrounds have better scores than students without programming backgrounds.

Finally, if students are able to successfully manage an introductory programming class with the exposures we describe above, they will be able to smoothly transition into learning SA&D. Therefore, this gives rise to the following hypothesis:

Hypothesis 4 (H4): A student's weighted total is positively associated with his/her programming knowledge. Students with programming backgrounds have better scores than students without programming backgrounds.

The four hypotheses are depicted in Figure 1.

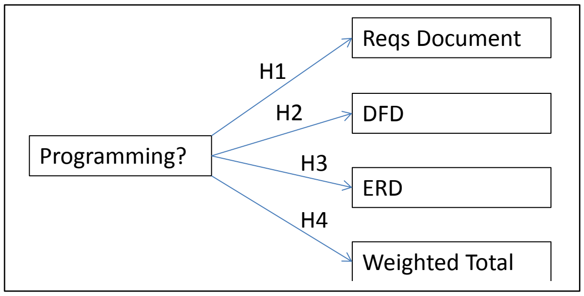


Figure 1: Hypotheses Testing

5. DATA ANALYSIS

The scores of three assignments, i.e. requirements document, DFD design, ERD design, and the weighted total of each student have been collected for the 15 classes that the author has taught since 2007. A total of 259 student records were collected, in which 10 of them had missing data and were subsequently discarded. A total of 249 of them have been used in this study. Each student record has 7 attributes. They are summarized in Table 2 below:

Student Record Structure in Analysis		
Attribute	Description	Attribute Value
ID	Identifier to the record	Integer
Class	The class that the student enrolled in.	Integer (1..15) for the 15 classes the author taught since 2007
IS?	Is the student an IS or IS-related student?	Boolean, 0=non-IS , 1= IS/IS-related
PROG?	Has the student taken any programming?	Boolean, 0=no, 1= yes
REQ	Score of the requirements document	Rounded up integer (0..100)
DFD	Score of the DFD design assignment	Rounded up integer (0..100)
ERD	Score of the ERD design assignment	Rounded up integer (0..100)
Weighted Total	The weighted average of all scores, including other homework assignments and tests of the student	Percentage (0..100%)

Table 2: Student Record Structure in the Empirical Study

The data were loaded to SPSS version 21 for statistical analysis. Among the 249 students analyzed, 114 were non-IS students, while 135 were IS-related students. All non-IS students in this sample did not have any programming background prior to CIS372, while 14 out of the 135 IS-related students did not take programming classes prior to CIS372. The summary is tabulated in Table 3 below.

		Programming?		Total
		No	Yes	
IS?	No	114	0	114
	Yes	14	121	135
Total		128	121	249

Table 3: IS/Non-IS with Programming Background Summary

Their descriptive statistics are summarized in Table 4 below.

Group Statistics					
	PROG?	N	Mean	Std. Dev	Std. Error Mean
REQ	Yes	121	78.5840	22.65005	2.05910
	No	128	69.6641	27.57173	2.43702
DFD	Yes	121	63.9669	29.03358	2.63942
	No	128	54.9375	29.82708	2.63637
ERD	Yes	121	66.1653	27.38958	2.48996
	No	128	53.6719	30.02941	2.65425
Weighted Total	Yes	121	74.3473%	13.02708%	1.18428%
	No	128	68.2066%	13.91950%	1.23032%

Table 4: Descriptive Statistics of the Empirical Study

t-test

The mean scores of the requirements document, DFD design, ERD design, and the overall weighted total in Table 4 reveals that students with programming backgrounds performed better than students without any experience. The consistency and validity of the test scores are justifiable because the assignments have similar degrees of difficulty and were graded by the same instructor for a period of six years. To further analyze the data, independent sample t-tests were conducted in SPSS where the Grouping Variable is the PROG?, and the Test Variables are the REQ, DFD, ERD, and Weighted

Total. The null hypotheses predict that the mean scores of the Test Variables are the same between students who had taken programming classes prior to taking CIS 372 and students who had not.

The t-test results are summarized in Table 5.

	t-test for Equality of Means				
	t	df	Sig. (2-tail)	Mean Difference	Std. Error Difference
REQ	2.781	247	.006	8.91996	3.20798
DFD	2.419	247	.016	9.02944	3.73338
ERD	3.424	247	.001	12.49341	3.64880
Weighted Total	3.589	247	.000	6.14071%	1.71088%

Table 5: Independent Samples t-test Results (alpha = 0.05)

The t-test results clearly support the four hypotheses shown in Figure 1. It is not surprising that students with programming experience perform better in DFD and ERD than those with no experience. After all, these two technical skills are equivalent to skills used in programming. However, it is interesting to note that students with programming knowledge also outperformed students without programming knowledge in the requirements document assignment. This may be explained by the fact that functional requirements are similar to functional and procedural descriptions in programming exercises. Requirements are written at a higher level of abstraction but are still modular in nature.

Regression Analysis

The author further performed a linear regression as a predictive model to measure the potential student completion success of the course. The dependent variable is the Weighted Total, the independent variables are the scores of the requirements document, the DFD and ERD assignment scores, and the control variables are the IS?, PROG? and Class. The regression results are summarized in Table 6.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.248[a]	.061	.050	13.46328 %
2	.705[b]	.497	.484	9.92102%
a. Predictors: (Constant), Prog, Class, IS				
b. Predictors: (Constant), Prog, Class, IS, REQ, DFD, ERD				

Coefficients[a]						
Model		Unstandardized Coefficients		Stand. Coeff	t	Sig.
		B	Std. Err	Beta		
1	Const	70.990	2.139		33.189	.000
	Class	-.348	.203	-.106	-1.711	.088
	IS	1.268	3.817	.046	.332	.740
	Prog	4.876	3.802	.177	1.282	.201
2	Const	42.355	2.633		16.083	.000
	Class	-.050	.152	-.015	-.331	.741
	IS	1.833	2.816	.066	.651	.516
	Prog	-.067	2.822	-.002	-.024	.981
	REQ	.118	.027	.218	4.405	.000
	DFD	.175	.023	.376	7.597	.000
	ERD	.154	.024	.329	6.474	.000
a. Dependent Variable: WeightedTotal						

Table 6: Linear Regression Analysis Results

The regression analysis results in Model 2 show that the scores of the requirements document, DFD, and ERD are all significant at the 0.05 alpha level, confirming the results of the t-test above. Hence, the regression equation is:

$$\text{WeightedTotal} = 42.355+0.175\times \text{DFD}+0.154\times \text{ERD}+0.118\times \text{REQ}$$

The coefficients of the DFD, ERD, and REQ are 17.5%, 15.4% and 11.8%, respectively. Tellingly, while these three assignments amount to only 25% of the total course requirements, the adjusted R^2 is at 0.484. This suggests that, among all other assignments and tests, the scores of these three assignments alone can explain almost 50% of a student’s overall performance.

6. DISCUSSION AND CONCLUDING REMARKS

Results of the empirical study strongly suggest that students with programming experience will complete the course more successfully than those who don’t have experience.

Why is programming so important in learning SA&D? In a paper written by Professor David Gries at a 1974 ACM conference, he points out that general problem-solving is very unique in teaching programming (Gries, 1974). In the same paper, Gries illustrates his arguments and summarizes a four-phase process in problem-solving proposed by Polya in 1945 (Polya, 1945). This process is nearly identical to what is known today as SDLC. See Table 7 below for the comparison.

Polya's 4-Phase Process	**SDLC**
Understand the Problem	Planning
	Analysis
Devise a plan	Design
Carry out the plan	Implementation
Look back	Support/Enhancement

Table 7 Polya's Problem Solving Process vs SDLC

In fact, Polya's four-phase problem-solving process already suggests the incremental and iterative approach that we currently consider best practice. In Gries' words, "In a programming course, we attempt to teach the student how to program anything that can be programmed -- that has an algorithmic solution" (Gries, 1974, page 81). This "algorithmic" discipline and training empowers students to solve programs in a systematic way. With this training, students can smoothly transition to software engineering or SA&D, in which they cope with the complexity of solving larger problems in a more conceptual and abstract manner.

Jeffries, et al. studied the processes involved in designing software, and concluded that the decomposition process is central to creating the design (Jeffries, et al., 1981). The process is similar to the stepwise refinement proposed by Wirth; decomposition and stepwise refinement are usually covered in introductory programming class (Wirth, 1971).

The recent IS 2010 curriculum excludes programming from the core requirements even though Systems Analysis and Design (2010.6) remains one of the seven core courses in the guidelines (Topi, et al, 2010). The guidelines proposed in 2010.6 have further replaced technical skills, such as structured and object-oriented approaches, with the less programming-oriented business process modeling. It is undeniable that these replaced technical skills are crucial for students intending to further develop their careers in application development and system analysis. In a recent survey conducted by *The Economist*, 38% of respondents admit that "inadequate technical skill sets" are the biggest challenges for CIOs trying to align technology use with business goals, while only 21% think "inadequate management skills" are the biggest challenge (The Economist, 2013). Another study from the U.K. reports that almost 75% of current IT leaders -- an overwhelming majority -- are unsure that the CIOs of today will still be the right people to lead IT businesses in 2018 (Nice, 2013). Nearly half (43%) of the respondents are concerned by their potential deficiency in technical skills.

Time and time again we are reminded that the critical skills of an IT manager include project management, communication, writing, etc. While we all agree that these soft skills are crucial competencies for an IT manager, they do not necessarily mandate an undergraduate IS curriculum. Realistically, most undergraduate IS students will not be hired for management positions right after graduation. A technical position is still most likely be the first job for many IS graduates. Consider the current IS/IT job markets: reports show that programming and application development is one of the top 10 hottest IT skills for 2013 and 2014 (Pratt, 2012; Brandel, 2014; Simoneau, 2014; Wakefield, 2014). Another report suggests that 60% of the surveyed companies claimed they would hire more developers in 2013 (Pratt, 2012). Most recently, *U.S. News & World Report* named computer systems analysts as second place in their ranking of 2014's best jobs (Best Jobs, 2013).

If we intend to maximize the ability of our IS students to successfully find employment, it is our responsibility to properly equip them with sufficient technical skills. For that reason, it is necessary to continue encouraging programming as a pre-requisite to Systems Analysis and Design.

7. REFERENCES

Bajaj, Akhilesh, Batra, Dinesh, Hevner, Alan, Parsons, Jeffrey and Siau, Keng. (2005). Systems Analysis and Design: Should We Be Researching What We Teach? *Communications of the Association for Information Systems* (Volume 15, 2005)478-493

Best Jobs 2013 (2013). US News. Retrieved from: http://money.usnews.com/careers/best-jobs/computer-systems-analyst

Boberic-Krsticev, Danijela and Tesendic, Danijela (2013), Experience in Teaching OOAD to Various Students, *Informatics in Education*, 2013, Vol. 12, No. 1, 43-58

Booch, Grady (1986). "Object-Oriented Development", *IEEE Transactions on Software Engineering*, Vol. SE-12, No. 2. February, 1986.

Booch, Grady (1994). Object-oriented Analysis and Design with Applications. 2nd Edition, the Benjamin/Cummings Publishing Company, Inc., 1994, page viii.

Booth, S. (2001). "Learning Computer Science and Engineering in Context." *Computer Science Education*, 11(3), 169-188.

Brandel, Mary. (2014). 8 hot IT skills for 2014. Computer World, September 23, 2013. Retrieved from: http://www.computerworld.com/s/article/9242548/8_hot_IT_skills_for_2014

Chen, Brady, 2006. Teaching Systems Analysis and Design: Bringing the Real World into the Classroom, *Information Systems Education Journal*, Volume 4, Number 84, September 27, 2006.
http://isedj.org/4/84/

Gorgone, John, Davis, Gordon, Valacich, Joseph, Topi, Heikki, Feinstein, David and Longenerecker, Herbert (2002). "IS 2002 Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems", by ACM, AIS and AITP. Retrieved from: http://www.acm.org/education/is2002.pdf

Gries, David (1974). "What should we teach in an introductory programming course?", *SIGCSE Bull*. 6, 1 (January 1974), 81-89. DOI=10.1145/953057.810447
URL: http://doi.acm.org/10.1145/953057.810447

Guthrie, R.W. (2004). Integrating programming and systems analysis course content: resolving the chicken-or-the-egg dilemma in introductory IS courses. *Information Systems Education Journal,* 2(1).

Hammer, Michael (1990). Reengineering Work: Don't Automate, Obliterate. *Harvard Business Review*, July-August 1990.

Hodgson, Lynda, and Wynne, James (2012). "Adopting the IS 2010 Model Curriculum: A Survey of Top MIS Programs", *Southeast Decision Sciences Institute (SEDSI)* 2012 Annual Meeting, Conference Proceedings, February 2012, pp. 177-188.

IDC Research (2010). IDC Research, July 2010
http://www.enterpriseittools.com/sites/default/files/SAP_whitepaper1012.pdf

Information Week (2013). 2014 IT Budget Survey of organizations with 50 or more employees, October, 2013.
http://www.informationweek.com/strategic-cio/executive-insights-and-innovation/2014-it-budget-survey/d/d-id/1112715

IS 2010 Task Force (2009). Response Document. Retrieved from: http://cis.bentley.edu/htopi/IS2010Response_10-27-2009.pdf

Jeffries, R., Turner, A. A., Polson, P. G. & Atwood, M. E. (1981). "The processes involved in designing software", Cognitive skills and their acquisition. Edited by J. R. Anderson, Erlbaum, Hillsdale, NJ, 1981, pp. 255-283.

Keen, P. G. W. (1999). "Middle-Out Ideas," *Computerworld* (56), April 12, 1999.

Nice, Steve (2013). "Skills Gap: What Does 2018 Hold For The CIO?", Business Computing World. Retrieved from: http://www.businesscomputingworld.co.uk/skills-gap-what-does-2018-hold-for-the-cio/

Polya, G. (1945). How to Solve It. Princeton University Press, Princeton, N.J., 1945.

Pratt, Mary (2012). 10 hot IT skills for 2013. Computer World, September 24, 2012. Retrieved from: http://www.computerworld.com/s/article/9231486/10_hot_IT_skills_for_2013

Reich, B. H., and Benbasat, I. (2000). "Factors that Influence the Social Dimension of Alignment between Business and Information Technology Objectives," *MIS Quarterly* (24:1), March 2000, pp. 81-111.

Robey, Daniel (2001) "Blowing the whistle on troubled software projects", *Communications of the ACM* (44)4, pp. 87-93.

Rumbaugh, James, Balha, Michael, Lorensen, William, Eddy, Frederick , and Premerlani, William (1991). Object-Oriented Modeling and Design, Prentice-Hall, Inc., 1991. Page x in Preface.

Samson, Ted (2013). "Software developers expected to see the highest IT job growth come 2020", February 12, 2013. Retrieved from: http://www.infoworld.com/t/it-jobs/software-developers-expected-see-the-highest-it-job-growth-come-2020-212709

Satzinger, Jackson, and Burd (2007). Systems Analysis & Design In A Changing World, 4th Edition, 2007, Course Technology,

Shelly and Rosenblatt (2010). Systems Analysis and Design, Eighth Edition, Video Enhanced, Course Technology, 2010

Serva, Mark (1998). "Teaching Systems Analysis and Design to Non-IS Majors: A Management Simulation", Decision *Line*, July 1998.

Simoneau, Paul (2014). "The Top Ten IT Skills for 2014", Global Knowledge. Retrieved from: http://www.globalknowledge.com/training/generic.asp?pageid=3635

Sims-Knight, Judith and Upchurch, Richard (1993). "Teaching Object-oriented Design Without Programming: A Progress Report", *Computer Science Education*, 4, 135-156.

Stack Overflow (2013). Stack Overflow Discussion Forum: "Teaching systems analysis and design - how much programming experience is needed?" Retrieved from: http://stackoverflow.com/questions/382797/teaching-systems-analysis-and-design-how-much-programming-experience-is-needed

Sulinier, Bruce and White, Bruce (2011). "IS 2010 and ABET accreditation: an analysis of ABET-accredited information systems programs", *Journal of Information Systems Education*, Dec 22, 2011.

Taylor, Dick (2013). Requirements Document Example. Retrieved from: www.ics.uci.edu/~taylor/ICS_52_FQ02/ics52_Fall02_Req_Ver3.doc

The Economist (2013). The strategic CIO- Risks, opportunities and outcomes. The Economist Intelligence Unit Limited 2013

Topi, H., Valacich, J. S., Wright, R. T., Kaiser, K. M., Nunamaker, Jr., J.F., Sipior, J.C., and de Vreede, G.J. (2010). IS 2010 Curriculum Guidelines for Undergraduate Degree Programs in Information Systems, ACM and AIS, 2010.

Wakefield, Kylie Jane (2014). Top IT Skills for 2014. Forbes, Transformational Tech, 4/22/2014. Retrieved from: http://www.forbes.com/sites/emc/2014/04/22/top-it-skills-for-2014/

Wirth, N. (1971). "Program development by stepwise refinement" *Communications of the Association for Computing Machinery*, Vol. 14, 1971, pp. 221-227.

Yourdon, Edward, and Constantine, Larry (1978). Structured Design – Fundamentals of a Discipline of Computer Program and Systems Design, Prentice-Hall, 1978. Page xvi.

First Database Course – Keeping it all Organized

Jeanne M Baugh
baugh@rmu.edu
Robert Morris University
Moon Township, PA 15108

Abstract

All Computer Information Systems programs require a database course for their majors. This paper describes an approach to such a course in which real world examples, both design projects and actual database application projects are incorporated throughout the semester. Students are expected to apply the traditional database concepts to actual database storage problems. The design of the database is emphasized and students evaluate each other's design as well as their final database project. The details of a database written by the Author to organize all information surrounding the student's project are also presented. In this database course, the students are able to follow the progress of their fellow students during the course. Student's evaluations of each other's work during the semester is shown to be beneficial in the learning process.

Keywords: Database first course, Real world projects, Database project, IS education

1. INTRODUCTION

All students in an Information Systems degree are usually required to take one database course as part of the core for the major (IS2010, Model Curriculum and Guidelines-http--www.acm.org-education-curricula). Such a course would emphasize database design and implementation based on a thorough analysis of requirements and information modeling. An introduction to relational database technology would be provided, highlighting the use of Structured Query Language (SQL) and report generation. An advanced course could go into more detail in the areas of advanced SQL considerations, PL/SQL, database performance and security issues, multimedia, parallel, and distributed database management systems, data warehousing, and object-oriented databases. At the Author's institution, the undergraduate student takes only the first, beginning course.

In the database course described in this paper, students are given as much real world experience as possible. Therefore, a great deal of time is spent in design work of simulated real world problems as well as a detailed design of the student's individual semester project. If the course material can be made more interesting to the student, then he will be more inclined to want to learn it. Real world projects allow the students to "learn better through a particular domain of their interest" and "see the practical value of what they learned" (Robbert, Wang, Guimaraes & Myers, 2000). Others have had success with a "real world" approach, such as the partnership of a university with a large insurance company to implement database assignments for introductory and advanced database courses (Seyed-Abbassi, King & Wiseman, 2007). To give students such experiences in the "real world", a bridge must be established between business and academia (Courte & Bishop-Clark, 2005). In teaching beginning database for many years, it has been the Author's experience that students have a relatively naive view of the complexity of real-world business.

Additionally, students are expected to also communicate with actual users. (Baugh, Davis, Kovacs, Scarpino & Wood, 2009). Database programming skills along with communication skills go hand in hand for successful employment (Seyed-Abbassi, King & Wiseman, 2007). In fact, employers do demand this of their entry level employees (Gruba & Al-Mahmood, 2004). Thus, large semester projects along with documentation should be key elements of any database course (Ehie, 2002). And, gaining practical experience is invaluable when the student is on that first job search.

Database Course Emphasizing Design Work

Two different approaches to teaching a database course could be used. One focuses on the actual application software, Oracle, SQL Server etc… The other focuses on the theory of database design and implementation, with the vehicle (the database package) being secondary. This paper describes the later approach. A database can not be implemented until the design is clean (Deperlioglu, Sarpkaya & Ergun, 2011). Or perhaps better stated, it can not be implemented successfully if there are normalization problems.

This Author has worked as a database consultant for many years, with the most recent projects being complicated databases in the orthopedic department of a large city hospital. Many of the Author's experiences are brought into the classroom. This allows the students to see what a database designer actually deals with in designing and implementing database projects for real users. Students are also given actually database problems from live medical databases (with data scrubbed out, of course).

Database design is a major element of the course work described in this paper. The students were told on the first day of the course that design would be the hardest thing they would do during the course (Connolly, & Begg, 2005). After a few weeks, the students did believe this! It is the Author's opinion that many of the database text books do not spend enough time teaching the actual design of a database (Philip, 2007). In this course, the students spend at least a month on database design only, before they actually work with any physical database in the computer.

The students are provided with many examples of interactions with users (Hansen, 2012). Communication skills of the database designer are extremely important (Codd, 1971). Students are taught to "listen" to the user. Students not only need to hone their technical skills, but they need to develop a communication expertise that will allow them the best possible chance at drawing out of the user what their data needs may be. Often the users will not know what to tell the database designer about their data needs. Sometimes they will even try to tell the designer what actual fields should be in a table. They will speak in terms of the outcomes of the database, for example the desired reports. Students are taught to take those required reports and "back design" the database from them. They are also taught to ask questions (as many as possible) to help understand how all of the data fits together. For example, if they are designing a surgical database, and they are told that the Doctor wants to store the type of anesthesia used in the surgery, the student should then ask if there can be more than one anesthesia administered during the surgery. The students are provided with many examples of user issues and some "mistakes" the Author has had to deal with in designing and implementing databases at the hospital. The "anesthesia" is one mistake this Author made on an actual database. By not accounting for multiple anesthesia, the students saw that a mistake can cause a major database table change. They were able to appreciate how difficult it was to deal with this mistake after 6 months of data had been entered. Seeing how actual design errors cause very big problems is a valuable tool. By knowing what the user expects from the database, the design can be adjusted accordingly before data has ever been entered.

Although database text books contain design assignments and projects, this Author has written many the students work through. The kind of text that is written in these design assignments has come from this Author's many years of dealing with users and helping them define what their needs really are. The Author acts as the user in these scenarios and students must ask as many questions as possible of the user to understand what the design should be. A few examples of these design problems are listed below. (The students were to create the Entity Relationship diagram for each problem). An entity is a distinguishable item and a relationship is the connection between the sets of entities.

a. You and your family have an internet business selling items on EBay. You are having some problems keeping track of which items belong to which individual. You have been asked by your family to organize the EBay records. (some of your items are also consignment items from friends and others) Associated with the sale of the item you will have shipping information, including the customer who purchased the item. The reports you will need include:

- All information on items sold within a specific time frame
- Which family member (or friend) is selling the most items
- All open auctions
- List of all shipping costs
- Newsletter to all customers
- History of the bids on each item

b. You are the coach for a youth soccer team. Your players are children between the ages of 6 and 8. You have both male and female members on your team. You not only want to keep track of goals scored and who the opponents were, you must also know who played in the games, because the players will get a trophy if they attend all 10 games. You must also keep track of who is allowed to pick up each child after practice (the guardian). (Every individual guardian must be listed for each player) The reports you will need include:

- List of all players and their guardians
- Record of the games won and lost along with the opponent
- List of all goals each player scored and against which opponent
- List of all players attending each game
- Mailing list for the end of year banquet

The students used these and many other simulated problem statements to work through Entity-Relationship (E-R) diagrams. Often the students worked on these problems in groups. The solution E-R diagram for each was then provided to the students. The youth soccer solution is provided in Figure 1. in the appendix.

A number of assists/or shortcuts have been developed by the Author to help the student to create the E-R diagrams. For example, the students are taught to listen for any plural words in the problem statements. (a patient has **surgeries**, a student is enrolled in **courses**, an insurance agent has **clients**) When a plural exists, that is an indication that the entities should not be stored together. The E-R diagram for the patient and surgeries is in Figure 2 in the appendix.

Another assist the Author has presented concerning the E-R design is a somewhat easy way to define the cardinality. In the example in Figure 2 in the appendix, cardinality is the relationship between the patient entity set and the surgery entity set. The relationship is a diamond in the diagram and in this diagram it is called "Has". Is the relationship one-to-one, one-to-many, or many-to-many? Defining the type of relationship is often very difficult for the first time database student (Seyed-Abbassi et al., 2007). The students are taught to start with one of the entities in the relationship and ask if each of those entities can have multiple connections on the other side. If they say Yes, then an "M" is placed on the other side. Then they move to the other side of the relationship and ask the same question in the opposite direction. Using the E-R diagram in Figure 2, the method is applied as such:

Start with the Patient entity set and ask "Can each patient have multiple surgeries"? If the answer is YES, then an "M" is placed next to the surgery entity set. Then go to the surgery set side and ask, "Can a surgery be related to more than one patient "? In this case the answer is NO, so a "1" is placed next to the Patient entity set. This method will work, no matter which entity set you may start with. This is not the notation database books use for cardinalities, but in learning to create the designs, students do well with this method. Later in the semester the standard notations are discussed (Foltz , O'Hara & Wise, 2004) (for example, (1:N) or (M:N) or (1:1)). Students are also given examples of multiple relationships. One example of this is the special case when one of the related entities participates as 1 and the others as N.

After the students have had about a month of design work, they then work with translating the design into an actual database. This process can also be somewhat difficult for the beginning database student. The normalization process is studied later in the semester, but a few rules are defined for the students to help insure that the resulting database will have as few normalization problems as possible.
The rules for defining the physical database from the E-R diagram are:

- Entity Sets (rectangles) become tables
- Relationships (diamonds) that are one to many, do not become tables, but the key from the one side has to be a field in the many side table
- Relationships (diamonds) that are many to many, become tables and the data in that table are **at least** the keys of the entity sets they relate

2. STUDENT INDIVIDUAL PROJECT

The students then move on to define their own databases project. They are asked to find a real project to implement. The Author approved the project based on the following guidelines:

- ✓ Was the idea a valid one? (a subjective judgment on the part of the Author)
- ✓ Was the problem something the student could reasonably finish in the time allotted?
- ✓ Would the design provide approximately 10 tables once implemented?
- ✓ Were there sufficient relationships among the data? (one to many, many to many, etc…)
- ✓ Were there sufficient attributes to be defined?

Some of the project created were:

- ✓ Database of Fundraisers and their Products
- ✓ Prospective student athlete information for the men's lacrosse team
- ✓ Well device and communication information for an oil & gas company
- ✓ Track services provided by a company with multiple types of audio visual meeting rooms for rent
- ✓ Sales incentive payment information for a financial services company
- ✓ Track information relating to children who attend a Church Sunday School
- ✓ Patient lab test Appointments and results

After approval of the initial database idea, the detailed design was done. Because they were doing work for a real user, it was important that their designs were correct (Choobineh & Lo, 2004). They provided a great deal of information concerning their database project and several passes were made to try to create a correct E-R design. The students presented and defended their designs in class. All students were encouraged to ask questions of fellow students and thus help them to define a correct design. By helping to work out problem with other's designs in the class, essentially the students are designing around 20 to 30 databases (depending on the size of the class each semester). At this point in the semester, the students really did not have enough experience in design work to know if their design was a good one or not. Since the student was creating a "real" project, this Author felt a responsibility to the users who have agreed to participate in the student's learning experience to ensure that the resulting database was correct. Therefore, the author made sure that the designs were correct before allowing the student move on to actually implement the database.

It became apparent to the Author that because each of the students were working on a different project with different issues, a way to organize this information was essential. Therefore, the Author wrote an Access database to store and track all information. The Author also created an Excel spreadsheet with various column headings related to information about the student's individual database project. After the student's database project had been approved, they each filled in a spreadsheet and sent it to the Author. The information was then imported into the Access database. All students were able to "view" the data in the database. Again, a "real world" database was used in the course. And, the "real world" issue of how to integrate spreadsheet data into an existing database was a teaching moment as well. Often data to be stored in a database may come from some external electronic source (Mahoney & Welch, 2006). Figure 3 in the appendix. shows a sample screen of imported data from a student who created a database for a friend who owned a bar. The data on the left of this figure was imported from the student's spreadsheet. And, on the right of this figure you can see several reports that were assigned to this student by the Author.

Students were given access to this database so they could not only track requirements assigned to them but also view a summary of the work of their fellow students. This database also kept track of individual problems or issues that must be addressed by each student. This database was a solution for the Author to the problems of:

- Keeping track of what each student was working on
- Keeping track of problems/ issues that each student must address for his individual database

- Keeping track of custom reports assigned to each student
- Keeping track of individual student E-R diagrams (these were imported into a field that was an OLE object. Please see Figure 4 in the appendix. For a student E-R Example)

Students in the course were also able to see the progress of all other student databases which were real world projects. Thus they experienced many issues beyond their own for their own database. Figure 5 in the appendix shows a sample screen of some issues a student had with his database implementation. The Author entered these issues/problems throughout the semester.

3. SQL LANGUAGE

In the database course, the students also learned SQL (Structured Query Language). They used this with the Author's sample databases as well as their own databases. For the most part, the students did use Access for their projects. However, some used Oracle or Sequel Server. But the students were required to use standard SQL at all times. Even though it is very easy to create tables in Access from the wizard screen they were required to write all data definition language (DDL) statements that would have been necessary for the creation of the tables in their database. These included statements to create the tables, primary keys, foreign keys and various constraints. The students were assigned a number of reports specific to their data by the Author. Again, the Author's Access database was essential to track what was assigned to each student. The students used SQL to create the underlying queries for the reports and then used the software features, such as the access report wizard, to create the actual reports from the SQL query statements. The students were also given a number of assignments using DDL statements and DML (data manipulation language statements). This Author is of the mindset that the actual database product used is not as important as the database topic to be mastered…in this case that being standard SQL.

4. NORMALIZATION

1. Students in a first database course must also be introduced to the process of normalization… (proving that the database design is a good one) Because of the "The rules for defining the physical database from the E-R diagram" referred to earlier in this paper, in most cases, the databases designs did not have too many problems. Students were to prove that all tables were in at least third normal form. A brief definition of first, second and third normal form is provided in Table 1 (http://edn.embarcadero. com/ article /25209)

<u>First Normal Form</u>	**<u>Second Normal Form</u>**	**<u>Third normal Form</u>**
- The table has a primary key. - No single attribute (column) has multiple values. - The non-key attributes (columns) depend on the primary key.	- The tables meet the criteria for first normal form. - If the primary key is a composite of attributes (contains multiple columns), the non key attributes (columns) must depend on the whole key.	- The tables meet the criteria for second normal form. - Each non-key attribute in a row does not depend on the entry in another key column.

Table 1. Brief summary of Normal Forms

5. STUDENT EVALUATION OF EACH OTHER'S PROJECTS

The students started on their individual database project by defending their designs to the entire class. As the semester progressed, they were able to track each other's progress on their database project by viewing the information contained in the course summary database. During the last week of class, they presented their final database projects to the class. They were broken into groups of 4 to 5 students. They presented their database project to their group and they critiqued each other's work. By having a small number of students in each group, it gave them sufficient time to really highlight their work. The Author observed a great deal of pride in their work as each student presented to their groups. They were told at the beginning of the course that they would present their work to the class, so most were well prepared for this event.

6. STUDENT SURVEY AND ATTITUDES

The Author has been teaching database similar to this for a number of years. In the Fall 2013 semester there were 35 students enrolled in the database course. The students reported that they had a high interest in completing the individual database project because it was a "real" assignment for a "real" user. Further, they said that they could not "put down" the database and spent many additional hours getting it to look and run "just right". Many of them also said that they added additional functionality beyond what was required and that they would take an advanced database course if given the opportunity.

In learning to design a database, how effective was it for you to see the critiquing of other student designs?	4.6
How did you feel about seeing other issues/problems students were having in the implementation of their database projects?	3.8
How did you feel about other students seeing your issues and problems with the implementation of your own project?	3.4
How did you feel about seeing the final project of others in the class?	4.9
How did you feel about demonstrating your project to others in the class?	4.2
How did you feel about evaluating other student database projects?	4.5
How did you feel about the amount of time that was spent on design work for the course?	3.9
How did you feel about the various real world designs presented during the semester?	4.8
How did you feel about the course database created to store all student project information?	4.1

Table 2. Student Survey Responses

There is existing research that supports the theory that one course is not enough for the computer student to adequately understand database topics (Schneider, 2006). The students were surveyed about their attitudes toward evaluating fellow student's work. The students were ask to rate each of the following questions on a scale of 1 to 5 with 1 being the least helpful to your learning experience and 5 being the most helpful to your learning experience. The questions and average response are shown in Table 2.

It was the Author's observation that the students are always more interested in a real project. By the end of the semester when the students presented their databases to the class, it was clear to see the pride on the face of those presenting. It was also just as rewarding for the Author to see students giving other fellow students accolades for their work.

Some of the student's comments reported on the survey include:

- "I appreciated the realism in that we'll occasionally be presented with projects where we don't know everything and sometimes have to get more detail"
- "I like the fact that you push designs because they're truly the foundation to a database"
- "It was helpful because I may have had an issue that another student may have been able to help me correct the issues"
- "I feel that it was a good option to demonstrate our databases in front of other students because it may help them with their databases and also they can ask questions on how to implement certain things on their databases"
- "I believe that evaluating other students databases and giving corrective criticism will help them be able to make their databases better"

7. CONCLUSION

This Author was able to bring many personal experiences as a database consultant into the classroom on a daily basis. The students benefitted from the discussions of real encounters with real users and real issues/problems. "Real" projects have always been a great way to get the student involved in what he is learning. This is especially true of a project that the student has selected for himself (Ehie, 2002). Students also learned a great deal from seeing what others are facing in the design and implementation of their projects. Having the students not only work with their own projects but others as well seems to be an aide to the learning process.

Another issue that is of importance and not mentioned in this paper is the area of dishonesty. When using a format such as the one discussed in this paper, there is no possible chance of students copying from each other. In fact, often one student would help a fellow student with a problem he might be having in his database project. This gave the student experiences with issues he might not have encountered in his own database.

If teaching a course in this manner, the Author has a few recommendations:

- ✓ Be careful to limit the scope of each student's project. The student may not realize that the project he wishes to do may be too much for someone new to database work. Also, the project must be completed in the semester time limit. Perhaps deleting some of the functionality he may wish to include will be necessary. By the end of the semester, he should be able to incorporate additional functionality on his own.
- ✓ Make sure students interact with the user often. Any issues concerning the user must be communicated to the instructor as soon as possible. It also might be a good idea for the instructor to briefly interact with the student's user a few times during the semester.
- ✓ A detailed evaluation of the design is necessary in order for the student to complete the database successfully. This will require a significant amount of time on the instructor's part. Because the students are new to database work, and the design is done first in the semester, they will need help to ensure that the design is a solid one.
- ✓ Create some way to organize what each student is working on. This Author wrote a database to store detailed information surrounding the student database projects. This database also allowed the students to keep track of what others in the class were working on. Thus, it gave them another outlet to examine "real world" projects.
- ✓ Find as many ways as possible of bringing real database experiences into the classroom. If the instructor is not doing actual database consulting work, bringing in a database programmer to talk to the class would be advisable. Any way that the students can understand what really happens in the "real world" is advantageous.
- ✓ Make sure the students create sample data for database development. Also, do not include sensitive user information in the student's database prototype. Make sure the user understands that the student's work may be shown in class and therefore user's private information must not be included.
- ✓ Make sure the students understand the grading rubric for the project. This could include an evaluation from the actual user. But is essential that students know how their grade is being calculated. This protects both the student and the faculty member.

This course will help the students become better database designers and implementers. They will come away with a wide range of practical knowledge that is not easily taught in a typical lecture setting. They will succeed in two arenas, technology and communication. It is becoming more and more important to bring "real" experiences into the classroom. The course described here is a step in the right direction (IS2010, Model Curriculum).

8. REFERENCES

Baugh,J.,Davis,G.,Kovacs,P. Scarpino, J., Wood,D. (2009). EMPLOYERS AND EDUCATORS WANT INFORMATION SYSTEMS GRADUATES TO BE ABLE TO COMMUNICATE, Issues in Information Systems, Vol X No 1. pp 198-207, 2009 (Also appears in The Proceedings of IACIS)

Choobineh, J., & Lo, A. W. (2004). CABSYDD: Case-Based System for Database Design. Journal Of Management Information Systems, 21(3), 281-314.

Codd, E.F. (1971)."Further Normalization of the Data Base Relational Model." (Presented at Courant Computer Science Symposia Series 6, "Data Base Systems," New York City, May 24th–25th) IBM Research

Connolly, T., & Begg, C. (2005). Database systems: A practical guide to design, implementation, and management. Reading, MA: Addison Wesley.

Courte, Jill and Bishop-Clark, Cathy (2005). "Bringing Industry and Educators Together," Proceedings of the 6th Conference on Information Technology Education, October 20-22, pp. 175-178.

Date, C. J. (2004). An introduction to database systems. Reading, MA: Addison-Wesley.

Deperlioglu, O., Sarpkaya, Y., & Ergun, E. (2011). Development of a Relational Database for Learning Management Systems. Turkish Online Journal Of Educational Technology - TOJET, 10(4), 107-120.

Ehie, I.C. (2002). "Developing management information systems (MIS) curriculum: perspectives from MIS practitioners", Journal of Education for Business, Vol. 77 No.3, pp.151-7.

Foltz , C. Bryan, O'Hara, Margaret T., Wise, Harold (2004). "Standardizing the MIS course: benefits and pitfalls", Campus-Wide Information Systems, Vol. 21 Iss: 4, pp.163 – 169

Gruba Paul, Al-Mahmood Reem (2004). "Strategies for communication skills development", ACE '04: Proceedings of the sixth conference on Australasian computing education - Volume 30

Hansen, Jorgen (2012). Practical Elements in Danish Engineering Programs, Including the European Project Semester, Industry and Higher Education, v26 n4 p328-335 Aug 2012. 8 pp.

http://edn.embarcadero.com/article/25209

IS2010, Model Curriculum and Guidelines-http--www.acm.org-education-curricula-S%202010%20ACM%20final.pdf

Kim, Youngbeom, Hsu, Jeffrey, and Stern, Mel (2006). "An Update on the IS/TT Skills Gap," Journal of Information Systems Education, Vol. 17, No. 4, Winter 2006, pp. 395-402.

Mahoney, L. S., & Welch, J. K. (2006). Click...and the Database Loads Into Excel. Journal Of Accountancy, 202(3), 53-57.

Philip, George C. (2007).Teaching Database Modeling and Design: Areas of Confusion and Helpful Hints, Journal, v6 p481-497 17 pp.

Report RJ909 (August 31st, 1971). Republished in Randall J. Rustin (ed.), Data Base Systems: Courant Computer Science Symposia Series 6. Prentice-Hall, 1972.

Robbert, Mary Ann; Wang, Ming; Guimaraes, Mario; Myers, Martha (2000). "The Database Course: What Must Be Taught," SIGCSE Bulletin Proceedings of 31st SIGCSE Technical Symposium on Computer Science Education, March, pp. 403-404.

Schneider, B. A. (2006). Hands-on Microsoft Access: a practical guide to improving your Access skills / Bob Schneider. Upper Saddle River, N.J.: Addison-Wesley, 2006.

Seyed-Abbassi, B., King, R., & Wiseman, E. (2007). The Development of a Teaching Strategy for Implementing a Real-World Business Project into Database Courses. Journal Of Information Systems Education, 18(3), 337-343.

Urban Susan D., Dietrich W. Suzanne (2001). "Advanced Database Concepts for Undergraduates: experience with Teaching a Second Course" SIGCSE Technical Symposium on Computer Science Education, February, Volume 33 Issue 1 pp357-361.

APPENDIX

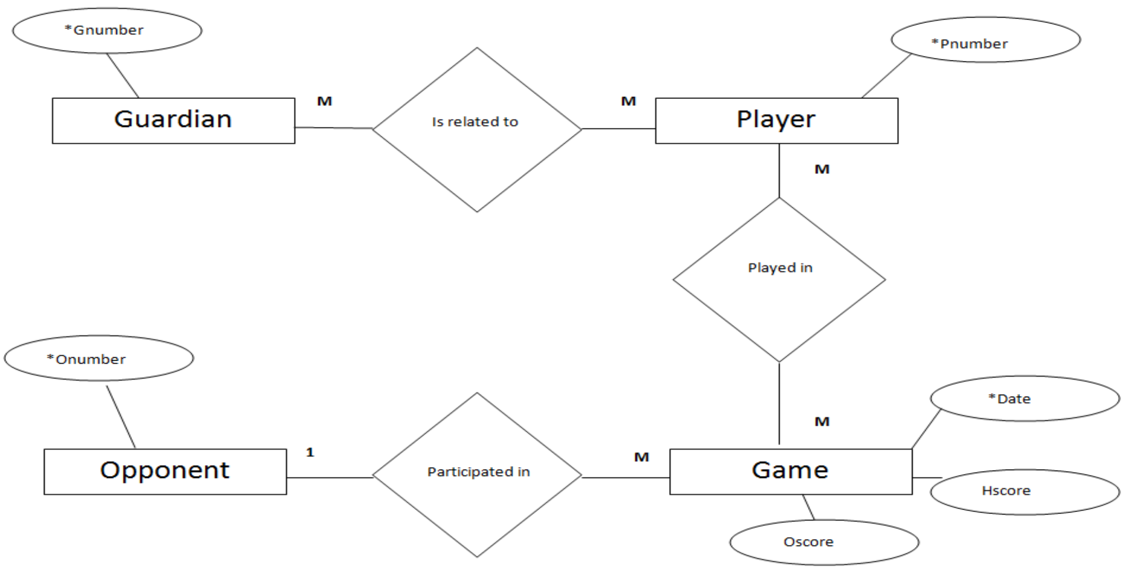


Figure 1. Solution to Youth Soccer Design Problem

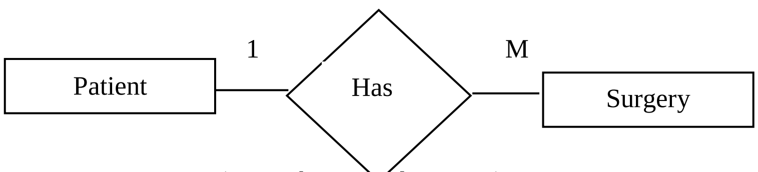


Figure 2. E-R Design (Patient has multiple surgery)

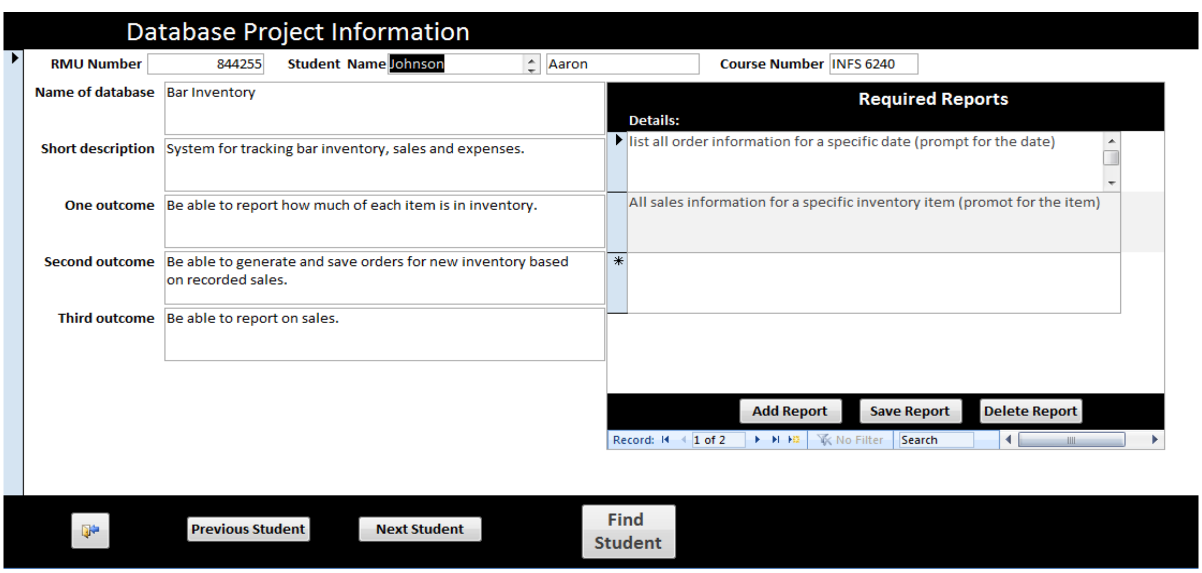


Figure 3. Sample screen of student database project

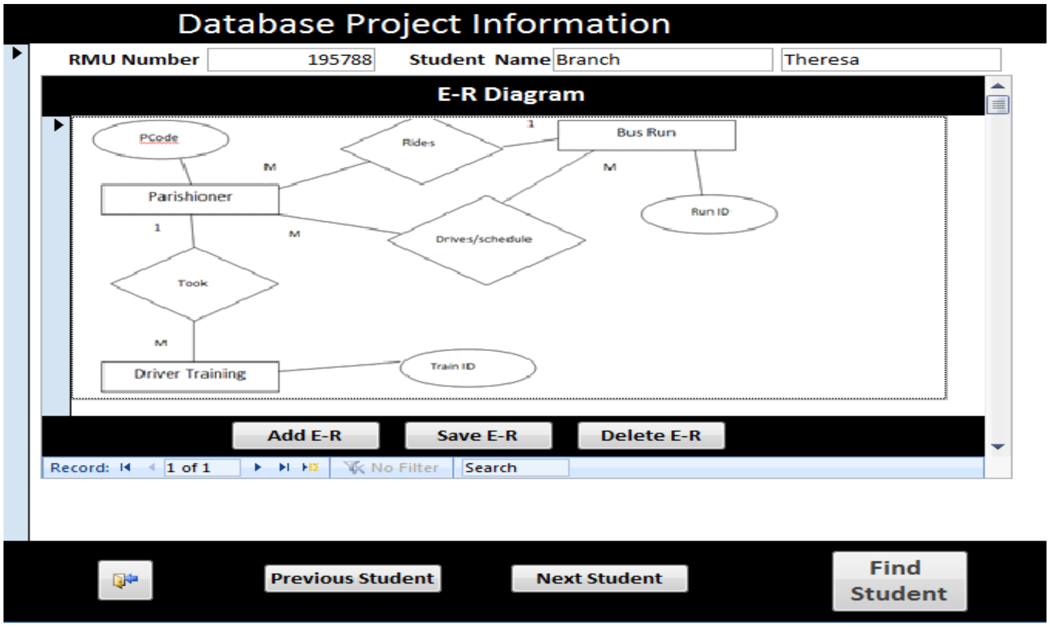


Figure 4. Student stored E-R diagram

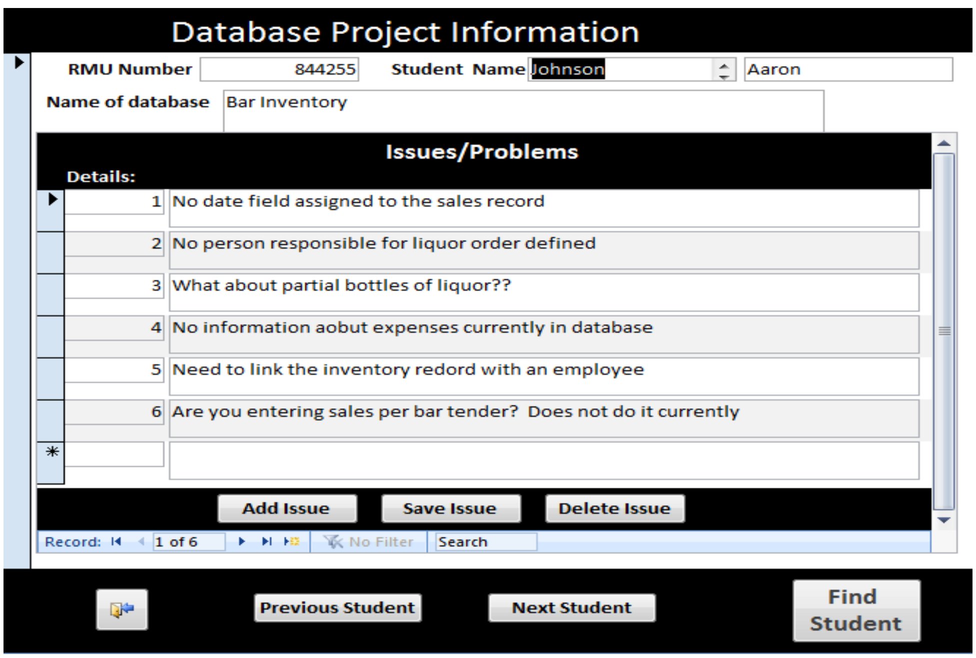


Figure 5. Sample screen of Student database project issues/problems

Including a Programming Course in General Education: Are We Doing Enough?

Roger C. Ferguson
roger.ferguson@gvsu.edu

Paul M. Leidig
paul.leidig@gvsu.edu

John H. Reynolds
john.reynolds@gvsu.edu

School of CIS
Grand Valley State University
Allendale, Michigan 49401, USA

Abstract

General education is more than a list of required courses a student must take to complete their degree. For most universities, general education is the groundwork for the student's university experience. These courses span multiple disciplines and allow students to experience a wide range of topics on their path to graduation. Programming classes, e.g., Introduction to Programming, have not typically been an option as part of a general education course sequence at most universities. This study found that, only half of universities offer any kind of programming course in the General Education (GenEd) Program. The data also show that only two-thirds of institutions offer a computing class of any kind as a general education option. Institutions with ABET accredited Information Systems (IS) programs are significantly lower in both of these categories. This paper demonstrates the reasoning and process for including a programming class as an option in a GenEd Program, thereby showing how a programming class can be used to satisfy the requirements of a general education course. This results in two significant advantages to the computing department and university since the departments expand their reach to many more students, with a potential of increasing the number of majors or minors within the department; and non-computing majors have the opportunity to take courses that have not traditionally been offered in the GenEd Program. The latter results in students receiving a more comprehensive education and exposure to skills in high demand.

Keywords: General Education, Programming Courses.

1. THE PURPOSE OF GENERAL EDUCATION

With few exceptions, colleges and universities require students to take a sequence of courses outside of their major, that allow students to expand their knowledge in areas such as ethics, social sciences, history, the arts, humanities, mathematical sciences, natural sciences, and many other areas of interest. These general education courses provide students with the ability to understand a variety of disciplinary perspectives. In addition, general education has a set of goals that help student understand one's own culture and the cultures of others as well.

A graduate with a general education based degree has the ability to think in broad terms, that is, outside of their respective major. Simply put, general education prepares students for life. Before a student graduates, every student in the college or university will have had a set of courses that prepares them for responsible citizenship, and the ability to think critically outside of their major. A generally educated person should have the ability to recognize and work with issues and/or problems from multiple perspectives.

For computing majors, a GenEd Program serves its intended purpose since the course work is significantly outside of their major. Courses in ethics and social sciences help future computing professionals make decisions that affect the direction of the computing field. Courses in the arts and humanities offer computing students a unique perspective in their own culture and the cultures of others. Unfortunately, many students outside of the computing field may not get the same level of benefit from general education. The reason is that, many non-technical majors already take courses in areas that general education typically covers. These majors are missing out on courses that would broaden their perspective. Courses in computing could begin to bridge this gap; resulting in a significantly enhanced general education for non-computing majors. There is an additional benefit in exposing non-traditional students to programming. By having non-computing majors take courses in the computing field, the number of minors or majors within the computing department may increase.

2. NON-COMPUTING MAJORS ARE AT A TECHNOLOGICAL DISADVANTAGE

The issue with general education is not with the concept of creating students with a well-rounded, life preparing experience. The problem is that general education does not produce this type of student in all majors. For a major in a technical field, general education serves these students very well, the courses are truly outside of their major. However, the problem is that for many majors, typically in a non-technical field, such as: history, foreign language, arts, philosophy, religious studies, etc., general education fails to give these majors a well-rounded, life-preparing experience with relevant skills. Regardless of choice of major, students should learn to use computing systems to access, process, and analyze information as an essential aspect of critical thinking and problem solving. In many disciplines, students should also learn how to design algorithms, to write programs, and implement computing solutions applicable to their professions. Recent papers and articles show that computer competency courses or basic "code literacy" is becoming a requirement for 21st century culture (Rushkof, 2012). Due to efforts of organizations such as Code.org and many educational institutions around the country, courses in coding look less like an extracurricular activity and more like a basic life skill. Some school districts have expanded such efforts to as early as second grade (Richtel, 2014). This literature shows the trend toward basic "code literacy" for a generally educated person will only get stronger.

Increasingly, an understanding of programming logic is seen as a requirement for participation in today's digital world. Prensky (2008) makes the point that when people acquired language, they didn't just learn how to listen, but also how to speak. When people acquired text, they didn't just learn how to read, but also how to write. Now that people have computers, they (i.e., non-computing majors) are learning to use them but not how to program them. Without this understanding, people must accept the devices they use with the limitations, or worse, the agendas their creators have built into them. Douglas Rushkoff in Program or Be Programmed says the real question is, "do we direct technology, or do we let ourselves be directed by it and those who have mastered it?" (Rushkoff, 2012)

As non-computing majors spend an increasing amount of time in digital environments where others have written the rules, not understanding these rules puts them at a disadvantage. Knowledge of the fundamental concepts of how computer code works can help users understand the limitations or intentions behind the code. Being literate of the logic behind the systems might encourage readers to stop accepting the products (e.g., websites, apps, etc.) at face value, and begin to engage critically and purposefully with them.

As Rushkoff (2012) claims, learning to code familiarizes people with the values of a digital society: how people collaborate and share information. This new way of thinking and processing is quickly replacing the industrial age value of the hoarding of knowledge. Learning how software is developed and how computer technology really works helps everyone understand how they will be working and living as a society.

With the advent of personal computers and off-the-shelf applications in the 1980s, education efforts saw a shift to teaching how to use computers for office productivity tasks such as word processing and creating presentations. The result was that pupils left school with little idea how computers work. The focus had shifted from teaching programming and creating applications, to teaching how to use software, yet provided little insight into how software was actually works. The use of digital technology is now so ubiquitous that many think a liberal education requires a foundation in understanding programming, just as much as biology, chemistry or physics. That is one reason for the increased interest in teaching coding. The fewer people who know the basics of computing fundamentals, the smaller the number of potential technically skilled employees there are. A growing percentage of jobs require "computational thinking"; the ability to formulate problems in such a way that they can be tackled by computers. (The Economist, 2014) The U.S. Chief Technology Officer, Todd Park, said,

> [T]technology and computers are very much at the core of our economy going forward. To be prepared for the demands of the 21st century — and to take advantage of its opportunities — it is essential that more of our students today learn basic computer programming skills, no matter what field of work they want to pursue (Adams and Mowers, 2013).

Many current open jobs requiring computing skills are outside of traditional technology fields. Simply knowing and understanding the programming process can enhance job skills and careers in areas outside of actual programming careers. In response to this growing need, and while everyone may not need to be a "coder", all students will benefit by learning enough about programming to communicate with programmers in the digital information age. As a place to start, providing one of two valuable core skills would help students become more code literate. First, is learning basic programming concepts, such as "if" conditional branches and "for" loops. This provides an understanding of the automation provided by computer programs and helps understand the lingo used by programmers to explain the logic required in an application. Secondly, with the ubiquitous nature of the internet and living on the web, knowing the basics of how web pages are created (e.g. basic java script) is a skill that would be very helpful, while demonstrating rudimental programming logic and syntax. While either of these skills is beneficial, taking a general programming course provides an ability to communicate better in the digital society.

3. COMPARING GENERAL EDUCATION PROGRAMS

To provide a snapshot of the current general education requirements and options as they relate to computing courses in general and programming courses in particular, the authors chose two specific and different groups. The first group contains two sub-groups, the first consisting of the 14 other public institutions in the state, while the second sub-group is made up of 11 additional peer institutions. Peer institutions, in this case, were defined by the institution's accreditation and assessment process as having similar degree offerings, mission, but not geographically located near the institution. GVSU has chosen to benchmark itself against these two sub-groups as one group of peer institutions and they will be treated as such for comparison purposes in this study.

The second group consists of the 38 individual institutions that have ABET accredited Information Systems (IS) programs as of April 2014. An ABET accredited group of schools was chosen as the group most likely to have institutions that place a premium on technology education and, therefore, would be the most likely to have a computing technology requirement and/or a programming course included as a general education options. The IS accredited group represents a subset of institutions that have ABET accredited programs that are most relevant to the audience for this paper, Information Systems educators.

In each case, the general education requirements and approved courses for each institution were analyzed using the content provided by that institution's web site.

1) Is any computing course on the approved list of general education courses?

> *H_1: Universities that have ABET accredited IS programs will be different in the percentage that have a computing course on the approved list of general education courses.*

2) Of these approved courses, are any a programming class (defined as a course that teaches programming logic as part of its content)?

> *H_2: Universities that have ABET accredited IS programs will be different in the percentage that have a programming course on the approved list of general education courses.*

3) Of these approved courses, are any an introductory computing course (defined as a course in general computer literacy, use of office productivity tools, and/or information literacy and use)?

> *H_3: Universities that have ABET accredited IS programs will be different in the percentage that have an introductory computing course on the approved list of general education courses.*

4) Is at least one of the approved general education computing courses required of all students?

> *H_4: Universities that have ABET accredited IS programs will be different in the percentage that require a computing course on the approved list of general education courses of all majors*.

Regarding creation and enforcement of general education requirements, some institutions allow general education to be controlled at the department level, where others allow easy substitution within the GenEd Program. These later schools were counted as those who had the choice of a programming course in the GenEd Program.

Some institutions had a specific programming class in the GenEd Program, but others allowed a choice of any programming class as a general education class. Both of these were counted as having a programming course in the GenEd Program; however when a course was defined as having some programming content in addition to other computing literacy content, it was counted as an introductory computing course.

Statistical Methodology

For each of the four hypotheses, the null hypothesis will be accepted or rejected using the significance level of .05. To compare two independent groups based on binary variables, most statistics guidelines suggest using the chi-square test of independence as long as the sample sizes are large enough. Sauro and Lewis (2008) contend, however, that the "latest research suggests that a slight adjustment to the standard chi-square test, and equivalently to the two-proportion test, generates the best results for almost all sample sizes" (p. 75).

To determine whether a sample size is adequate for the chi-square test, calculate the expected cell counts in the 2x2 table to determine if they are greater than 5. Since the values in this study pass this test, the data was evaluated using the standard chi-square test. Next, since some might classify the sample sizes too small, the N-1 chi-square test was also run. The results were nearly identical, but the actual p-values used were from the latter test since they gave a slightly more conservative result. The formula for the N-1 chi-square test (Sauro and Lewis, 2008) is shown below using the standard terminology from the 2x2 table:

$$\chi^2 = \frac{(ad - bc)^2 (N - 1)}{mnrs}$$

Test Results

Hypotheses are supported when the null hypothesis is rejected. In this study, the null hypothesis is rejected when there is a statistically significant difference between the proportions represented by $p<.05$. Accordingly, the first hypothesis (H_1) is supported since there is a significant difference between the 45% of IS Accredited Schools and the 72% of GVSU Peer Institutions that offer any computing class that is also eligible for general education credit. In addition, the second hypothesis (H_2) is supported since there is a significant difference between the 26% of IS Accredited Schools and the 56% of GVSU Peer Institutions that offer a programming class in the list of approved general education courses. Further underscoring the significance of these results is that these differences are not in the direction that was expected. Universities with ABET accredited IS programs have significantly lower percentages in both comparisons. Chart 1.0 shows the comparison of the proportions.

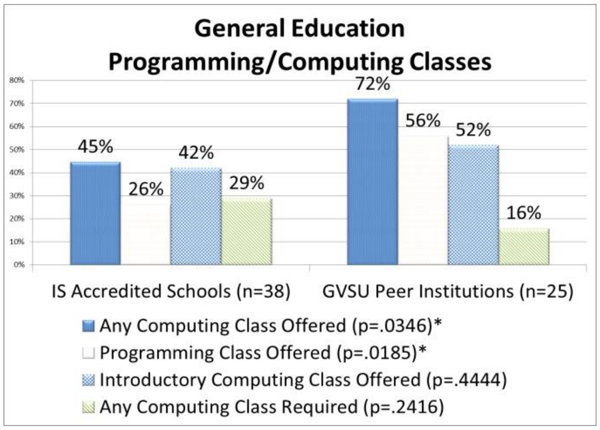


Chart 1.0 Survey results

4. FINDINGS

Based on these results, one can conclude there is an opportunity for universities to include a programming course in their general educational system. The graph shows only 28 percent of ABET accredited IS programs offer a general education approved programming course. If this number is representative of the general population of IS programs, then a significant number of institutions (the remaining 72 percent) could improve their GenEd Program for ALL majors.

The literature demonstrates that early computer education focused on teaching programming languages and logic. However, with the advent of personal computers and the use of purchased applications, universities shifted the focus to teaching how to use computers, often referred to as "computer literacy." This shift in focus occurred at the expense of understanding how computers work, and how to program them. The increased demand for people with computing (i.e. programming) skills is important in many different disciplines and careers shows the importance of returning basic computer knowledge to an understanding of programming, or how to make computers work.

These conclusions from the literature are confirmed by the analysis of GenEd Programs at peer institutions (survey result above). Not only were few institutions offering general computing courses (45% of IS accredited schools), even fewer were offering a programming logic course as part of the GenEd Program.

Based primarily on this review and analysis, the authors determined that it would be valuable to review the history of the computing courses in the GenEd Program at GVSU. The intent of this process is to provide a case study that might shed light on how institutions offer or require programming logic in GenEd Programs.

5. AN INTRODUCTORY PROGRAMMING CLASS IN THE GENERAL EDUCATION PROGRAM

This section examines GVSU's general educational program and the requirements for a course to be included in this program and demonstrates how a programming class can be included in general education. Since the GenEd Program at GVSU was recently revised in 2011 and since the programming class listed in that curriculum had not been revised in many years, it was decided that a thorough review should be undertaken. The process was to scan the environment, evaluate the current course and its history as a General Education course, and then evaluate the course from the point of view of the revised GenEd Program and current best practices in educational pedagogy related to that course.

The General Education Program - 1980's

The structure of the GenEd Program at Grand Valley State University remained largely unchanged from the 1986-1987 through the 1998-1999 academic catalogs. The requirements were divided into four major sections: College, Arts and Humanities, Natural Sciences, and Social Sciences. Each section had sub-groups of courses from which students were to choose individual courses based on the specified requirements as shown below.

1. College Section (one course in each)
   - Study of logical and mathematical quantitative reasoning
   - Foreign and multicultural approaches
   - History of Western civilization
   - Critical examinations of values and ideas
2. Arts and Humanities (one course in each)
   - Exploration of art, music, and theatre
   - Exploration of literature
3. Natural Sciences Section (one course in each and one of these must include a lab)
   - Physical sciences
   - Life sciences

4. Social Sciences Section (two courses, each from a different group and discipline)
   - Human behavior and experience
   - Social and cultural phenomena
   - Formal institutions

First General Education Programming Course

A course in BASIC was approved in fall of 1983 and added to the GVSU computing curriculum the next academic year. Three years later in the fall of 1986, the course was added to the GenEd Program for the following academic year under the College Section category of Quantitative and Logical Reasoning. The rationale for this is summed up in this one statement from the justification document submitted with the proposal, which says

> While the students do spend time in learning the syntax of a specific computer language, BASIC, the bulk of the time in this course is spent in learning problem solving and in relating the logical constructs of flow of control, organization of data, and inter-relationships between the sub-problems, to the given problem.

Revised General Education Program

As stated above, general education at GVSU has been part of the university since its inception. The "revised" main focus stated on the University's web site is: "…the general education program is to provide students with an education that balances depth with breadth, the specialized with the general. The general education program helps students become literate in a sophisticated way in a number of disciplines." There are two main goals in the GenED Program: Knowledge and Skills.

For Knowledge:

1. A graduating person from the GenEd Program is able to understand a variety of disciplinary perspectives, and understands the growth of knowledge and the various approaches through which the knowledge was acquired.
2. A generally educated person understands one's own culture and other cultures as well.
3. A graduating person understands how academic studies connect to current issues.

For Skills:

1. Learn the process of working together, i.e., collaboration through sharing of ideas towards a common project.
2. Critical and creative thinking using systematic reasoning to examine and evaluate ideas.
3. Use Ethical reasoning in the decision-making process based on defining systems of value.
4. Information literacy using multiple forms of information.
5. Integration, that is, the ability to synthesize and apply existing knowledge to complex problems.
6. To use effective practices in oral communication across a wide variety of public audiences.
7. Problem solving as it relates to open ended questions through the use of designing and evaluating the designs.
8. Quantitative literacy is competency working with numbers.
9. Written communication: the ability to create and refine messages that an educated reader would value.

The goals outlined above, knowledge and skills, are at the heart of the program. Students typically take 11 - 13 courses (over 30 credits) in the program. This is a significant commitment the university is making towards the GenEd Program.

The programming course that has been offered in the GenEd Program has been available to students since the 1987. The programming course satisfied the original requirements and continues to satisfy the requirements for the new general educational program criteria. The next section demonstrates the mapping of the programming course to the original set of criteria.

Mapping a Programming Course to the New General Education Requirements

By mapping the course content with the GenEd Program criteria, this section shows how a programming course can be used to satisfy the requirements of the GenEd Program at GVSU. Specifically, it addresses how a programming course might be used "to provide students with an education that balances depth with breadth, the specialized with the general. In particular, would such a course help students become literate in a sophisticated way in a number of disciplines."

Assignments/ projects in the Programming Course **Maps** →	**Criteria in a general education course**
Group Projects Create exercises to establish effective groups	Skill 1: Collaboration
Use Graphical User Design (GUI) with multi-buttons, text fields, labels, combo-boxes, data fields, etc. Visual studio is an excellent tool for this since it is a drag and drop, and prototyping environment	Skill 4: Information literacy, multi-forms of data Skill 7: Problem solving as it relates to open ended questions
Use complex programming structures The project should use nested while loops, nested if statements, etc.	Skill 2: Critical and creative thinking using systematic reasoning
Have periodic Code reviews Have each group gives an oral presentation of their code	Skill 6: Practice and refine oral communication
Assignments statements Have the project do non-trivial equations, e.g., have the program calculate the quadratic equation	Skill 8: Working with numbers
Comments within the code Require multi-iterations of the internal comments; consider the first set of comments as a draft	Skill 9: Written communication
Make the group project solve a real world problem Perhaps a simulation of a voting booth machine, discussion of the ethics behind this project	Skill 5: Integration; the ability to synthesize and apply existing knowledge to complex problems Skill 3: Ethics, what information should be retained.

Table 1 – Mapping a GenEd Course

Finally, this course should contribute to the two goals of providing both Knowledge and Skills. Table 1 provides a mapping of the projects in the programming course with the Skills criteria of GVSU's GenEd Program.

6. CONCLUSIONS

The process used in this analysis demonstrates that having a programming class in the GenEd Program has several benefits. First, the computing department expands their reach to non-majors that may result in an increase in majors or minors. Second, there is an immediate increase in the number of students serviced by the department, thus receiving exposure to additional skills. Finally, non-computing majors benefit by expanding their general educational course selection with relevant computing knowledge. This gives non-computing majors a broader multi-discipline degree, including skills that are in demand for many different careers.

The results also demonstrate that most institutions are not taking advantage of this opportunity. Only 56 percent of the peer institutions are utilizing a programming class in the GenEd Program. Furthermore, only 28 percent of ABET IS accredited universities are taking advantage of this opportunity. This does not mean that every university would benefit having a programming class in the GenEd Program. However, there does seem to be an opportunity for many computing departments to offer a programming course within the general education environment, benefiting both the department and the students taking the course.

The data and analysis from this study does not provide additional insight into the difference between simply offering versus requiring a programming course. However, based on the findings of the literature regarding the value of understanding programming logic for students in many non-computing majors, these authors suggest that requiring all students to take a general programming course provides an ability to communicate better in the digital society.

7. REFERENCES

Adams, Anna and Mowers, Helen (2013, October 30). Should Coding be the 'New Foreign Language' Requirement? *Edutopia*. Retrieved June 10, 2014 from http://www.edutopia.org/blog/coding-new-foreign-language-requirement-helen-mowers?page=1

The Economist (2014, April 26). A is for algorithm: A global push for more computer science in classrooms is starting to bear fruit. Retrieved from http://www.economist.com/news/international/21601250-global-push-more-computer-science-classrooms-starting-bear-fruit

Prensky, Marc (2008, January 13). Programming is the New Literacy. *Edutopia.* Retrieved April 23, 2010 from http://www.edutopia.org/programming-the-new-literacy

Richtel, Matt (2014, May 11). Reading, Writing, Arithmetic, and Lately, Coding. *The New York Times*. Retrieved from http://www.nytimes.com/2014/05/11/us/reading-writing-arithmetic-and-lately-coding.html?action=click&contentCollection=Politics&module=MostEmailed&version=Full&region=Marginalia&src=me&pgtype=article&_r=0

Rushkoff, Douglas (2012, November 13). Code Literacy: A 21st Century Requirement. *Edutopia*. Retrieved May 21, 2014 from http://www.edutopia.org/blog/code-literacy-21st-century-requirement-douglas-rushkoff

Sauro, Jeff and Lewis, James (2008). Quantifying *the User Experience: Practical Statistics for User Research.* Morgan Kaufmann, Burlington, Massachusetts.

Editor's Note:

This paper was selected for inclusion in the journal as an ISECON 2014 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 2014.

Appendix A - List of Universities in Study

ABET Accredited IS Programs
(as of April 2014)

1. Arkansas Tech University
2. California State University, Chico
3. California University of Pennsylvania
4. Drexel University, College of Information Science & Technology
5. East Tennessee State University
6. Fitchburg State University
7. Florida Memorial University
8. Gannon University
9. Grand Valley State University
10. Illinois State University
11. Jacksonville State University
12. James Madison University
13. Kennesaw State University
14. Metropolitan State University of Denver
15. New Jersey Institute of Technology
16. Quinnipiac University
17. Radford University
18. Regis University
19. Robert Morris University
20. Rowan University
21. Slippery Rock University
22. Southern Utah University
23. State University of New York at Brockport
24. The University of Tampa
25. University of Houston - Clear Lake
26. University of Houston, College of Technology
27. University of Nebraska at Omaha
28. University of North Alabama
29. University of North Florida
30. University of Puerto Rico at Bayamon
31. University of Puerto Rico, Rio Piedras Campus
32. University of South Alabama
33. University of South Carolina
34. Utah State University
35. Utah Valley University
36. Virginia Commonwealth University
37. West Texas A&M University
38. Wright State University

GVSU Peer Institutions
(as defined by Institutional Analysis Office)

1. Appalachian State University
2. Boise State University
3. Central Michigan University
4. CUNY Hunter College
5. Eastern Michigan University
6. Ferris State University
7. James Madison University
8. Lake Superior State University
9. Michigan State University
10. Michigan Technological University
11. Montclair State University
12. Northern Michigan University
13. Oakland University
14. Portland State University
15. Saginaw Valley State University
16. Towson University
17. University of Michigan-Ann Arbor
18. University of Michigan-Dearborn
19. University of Michigan-Flint
20. University of Nebraska at Omaha
21. University of Northern Iowa
22. Wayne State University
23. Western Michigan University
24. Western Washington University
25. Youngstown State University

Cryptocurrencies: Core Information Technology and Information System Fundamentals Enabling Currency Without Borders

Anthony Serapiglia
Anthony.Serapiglia@stvincent.edu
CIS Department
St. Vincent College
Latrobe, PA 15650

Constance Serapiglia
Serapiglia@rmu.edu
Robert Morris University
Coraopolis, PA 15108

Joshua McIntyre
Joshua.McIntyre@email.stvincent.edu
St. Vincent College
Latrobe, PA 15650

Abstract

Bitcoin, Litecoin, Dogecoin, et al 'cryptocurrencies' have enjoyed a meteoric rise in popularity and use as a way of performing transactions on the Internet and beyond. While gaining market valuations of billions of dollars and generating much popular press in doing so, little has been academically published on the Computer Science / Information Systems (CS/IS) foundations of this phenomena. This paper describes these foundations. In doing so, it is hoped that the success of the cryptocurrency payment systems can be used to demonstrate to CS/IS students how computer theory can be integrated into other disciplines with dramatic results.

Keywords: Bitcoin, Litecoin, Cryptography, Peer-to-Peer Networking, Mining, GPU

1. INTRODUCTION

The purpose of this paper is to add to academic literature concerning the cryptocurrency phenomena. Currently, there is precious little documentation and formal research in the area. The technology is fast moving and being pushed by a user community that is not traditional in research or business structure. Much of what is documented is available only through message boards, personal blogs, and live chats/personal messages within the user community (Schwartz, 2014). Because of this, there is a barrier in understanding and implementing cryptocurrencies. In the general media and to the general population there is a gap in awareness as to what is fact, and what is either gossip or rumor as to exactly what cryptocurrencies are, who is using them, and where the next evolutions of cryptocurrencies are going (Anderson & Rainie, 2014).

This paper will describe three underlying components of the infrastructure of cryptocurrencies and highlight the crossover of computing and information systems theory into the real world application. By bringing the cryptocurrency topic into the classroom, Computer Science /Information Systems (CS/IS) educators can excite a new generation of students by displaying how the underlying technologies have been combined to produce this far reaching and ground breaking innovation that has the potential to disrupt the world economy and become a standard without borders.

2. WHAT IS A CRYPTOCURRENCY?

Marshal McLuhan spoke of the Global Village well before the Internet tied the world together. The Internet has grown and matured to become the universal medium that McLuhan predicted would come (McLuhan, 1962). It has broken down barriers between peoples and nations, has crossed the boundaries of politics and religions, and has become a ubiquitous presence in the lives of the vast majority of people on earth. Language barriers have become lessened, machines talk to machines, and physical distance has become almost irrelevant. Where virtual reality was once the cutting edge of technology, the blended augmented reality of today has shown how a mature internet can be utilized to coexist with our physical world to allow for a greater capacity in nearly every aspect of a daily routine.

Integrating Information Sciences into existing disciplines has been a necessity for some time now. Disruptive innovations have been the catalyst for rapid change in almost every industry. Big Data and Data Analytics have allowed competition on equal footing in various markets and industries. One of the oldest industries in the world, the financial industry, is currently experiencing what may turn out to be one of the greatest disruptions it has faced in hundreds of years. The financial industry has seen its fair share of modernization and evolution in the past 40 years. Starting with a greater acceptance of credit cards, through ATM cards, to electronic stock trading and the ability to trade stocks as an individual – the financial industry has had a definite electronic evolution.

Currency, both physically and intrinsically, has also undergone change. The advent of the Euro as an idea in 1992, as an accounting currency in 1999, and as a physically circulating currency in 2002 was a major event in the history of world currency (Spahn, 2001). The advent of the common currency for the European zone saw the elimination of such venerable currencies as the Greek Drachma, the French Franc, and the Italian Lira amongst the 21 nationalist currencies that it replaced. Still, amongst the most traded currencies in the world: the US Dollar; the Euro; the Japanese Yen; and the English Pound (McFarlane, 2014) – all are what is considered "fiat" currencies.

Fiat money is a currency that is backed by the promise of a nation or entity that it will support the exchange of the physical representation of that money. It is not directly tied to a commodity, such as gold. The idea of the Gold Standard, that each bank note issued by a country is attached to a corresponding holding of physical gold equaling the amount of currency issued in value, has not been a reality for nearly a hundred years. The United States effectively went off of the gold standard in 1933 with a permanent detachment in 1971. The Bank of England abandoned the gold standard in 1931. Still, with these changes and others, there existed a backing entity in each currency. The United States backs the Dollar, Great Britain backs the Pound Sterling, and the European Central Bank backs the Euro.

In November 2008, the idea that currency had to be backed by a country or governmental entity began to be challenged in earnest. A paper began circulating on message boards titled, "Bitcoin: A Peer-to-Peer Electronic Cash System" authored anonymously by Satoshi Nakamoto. The paper proposed a "system for electronic transactions without relying on trust" (Nakamoto, 2008). A peer-to-peer network was proposed that would use individual 'mining clients' to perform work that creates a "coin" and verifies the transfer of ownership of these virtual coins (Nakamoto, 2008). The 'work' involves solving encrypted hash blocks, thus the true basis for the coin lies in cryptography. This has led to the use of the term "cryptocurrency" in describing the various forms of currency that have developed utilizing this process of mining.

To prevent inflation and the flooding of the market of coins, the work in solving the encrypted blocks becomes increasingly more difficult. The creation, or mining process, does not require a central authority to acknowledge the existence of a coin; records exist as a shared log on all individual clients that are connected to the network. This is referred to as the "block chain". The crossover between virtual and reality occurs in the exchange of the virtual coins for a currency that is physical. Value is negotiated through markets and currency exchanges that have sprung up with the increasing awareness and popularity of the virtual currency. These exchanges function much the same way other commodity markets function with direct buy and sell orders exchanged between individuals. As of June 12, 2014, 33 exchanges were recognized worldwide with active trading volume in Bitcoin (BTC) (Planet Bitcoin, 2014). However, these exchanges are non-regulated and operate outside of the traditional money markets. There is no safety net of law or government. Multiple incidents have occurred of fraud and theft that has become a major hurdle for general acceptance of cryptocurrencies to overcome. The exchange value of all of the cryptocurrencies has fluctuated wildly based on the smallest pieces of news or rumor (Nicklaus, 2014).

Bitcoin (BTC) is widely considered the "gold standard" of the new wave of cryptocurrencies. It was the first cryptocurrency, launched January 3, 2009 and has remained the most popular. As a comparison, as of June 12, 2014, 8 billion BTC existed in circulation (Crypto-Currency Market Capitalizations. 2014) this is comparable to 12 Trillion US Dollars and 951 billion Euros. As the popularity of Bitcoin rose, many factors contributed to the creation of other cryptocurrencies. These have become known as ALT-Coins in many circles as they are alternatives to Bitcoin. The main difference in the ALT-Coin is the encryption algorithm used in the creation of them. The leader of the ALT-Coin field is Litecoin (LTC). Litecoin has become widely known as the silver to Bitcoin gold (McFarlane, 2014). In June of 2014, 320 Million LTC were in circulation (Crypto-Currency Market Capitalizations. 2014). With the fluctuation in market price of cryptocurrencies so volatile, it is difficult to express the value of these currencies precisely. LTC saw a high of 11 November 2013 at $48.48USD, with June 12, 2014 price at $11.01USD (Bitfinex. 2014).

The wild fluctuations in value seen at the end of 2013 led to many derivatives of Litecoin to appear. While LTC has maintained a ratio of .25 to .17 exchange with BTC, many of the Alt-Coin derivatives exchange at extreme fractions. Some of the more notable Alt-Coins are:

DogeCoin (0.00000061 DOGE/BTC)
Dark Coin (0.01761860 DRK/BTC)
FeatherCoin (0.00006896 FTC/BTC)
PeerCoin (0.00284449 PPC/BTC)
NameCoin (0.00303992NMC/BTC)

By mid 2014, the flood of new coins had slowed and some market stabilization began to appear. Most new coins were met with skepticism and found it hard to gain traction amid speculation of scams and fraud (Morris, 2014).

Early 2014 also found the beginning stages of government involvement in defining how cryptocurrencies would be integrated into a larger economic system. January 28 and 29 of 2014 saw the state of New York Department of Financial Services hold official hearings on virtual currencies (Spaven, 2014) (Wile, 2014). The two days brought together many diverse interested parties in a fact finding mission to begin to set an agenda that could include the official licensing of currency exchanges that would openly and legally exchange cryptocurrencies for US Dollars under regulatory oversight. Later, the federal Internal Revenue Service issued directives leading up to tax season stating that it was the official stance for tax purposes that Bitcoin and other cryptocurrencies be treated as commodities rather than currency (Harpaz, 2014) (IRS.gov. 2014).

3. WHAT MAKES A CRYPTOCURRENCY?

In the initial paper that became the basis for Bitcoin, the need and motive behind the currency is explained as such:

> "Commerce on the Internet has come to rely almost exclusively on financial institutions serving as trusted third parties to process electronic payments. While the system works well enough for most transactions, it still suffers from the inherent weaknesses of the trust based model. Completely non-reversible transactions are not really possible, since financial institutions cannot avoid mediating disputes…..What is needed is an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact

directly with each other without the need for a trusted third party (Satoshi, p.1)."

The technologies that were brought together to accomplish this were already in place. The infrastructure of the cryptocurrency world is a very simple information system built of fundamental Computer Science concepts and techniques: Cryptography, processing architecture, and Peer-to-Peer Networking.

Cryptography
The basis of the currencies; their existence, ability to be exchanged, and the trust that they are valid, lies in cryptography. The coin itself is actually a chain of digital signatures exchanged utilizing public key encryption. A genesis 'block' is created by encrypting anything, in the case of Bitcoin a quote from "The Financial Times" is embedded in the block's binary data, "The Times 03/Jan/2009 Chancellor on brink of second bailout for banks" forming the basis of the hash brought into the first transaction (Bitcoin.it) (Blockexplorer.com). The public key of the receiver is combined with this hash and the signature of the sender. Subsequent transactions build upon this initial exchange with the hash included being built also upon the combination of the previous transaction content. The "coin" comes into existence as reward. For this system to be trusted there needs to be validation. This comes in the form of proof-of-work.

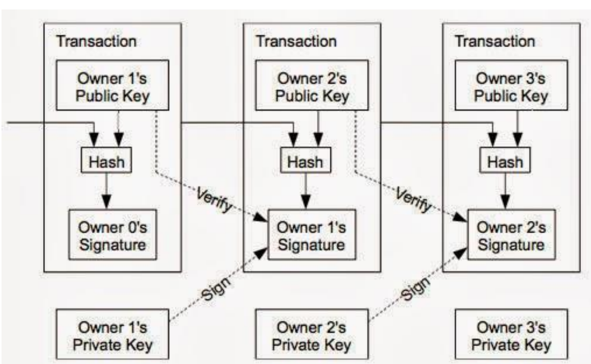


Diagram of a Bitcoin
from *Bitcoin: A Peer-to-Peer Electronic Cash System*, published in 2008 by "Satoshi Nakamoto".

For a transaction to be validated and included in the chain of transactions included in the blockchain, other members of the network need to verify it. A task is needed to be performed by clients on the network that prove the contents to be unaltered. A hash function is included in the protocol of the currency and is available to everyone taking part in the network. One method of proof of work validation is for a client to be required to add a number to the pending transaction that will result in a series of preceding zero's when hashed. The difficulty of this can be increased by varying the required number of zero's to be required. The Bitcoin proof-of-work puzzle requires the hash of a block's header to be lower than or equal to a number known as the target. The target is a 256-bit number (extremely large) that all Bitcoin clients share. The SHA-256 hash of a block's header must be lower than or equal to the current target for the block to be accepted by the network. The lower the target, the more difficult it is to generate a block. It is important to realize that block generation is not a long, set problem (like doing a million hashes), but more like a lottery. Each hash is basically a random number between 0 and the maximum value of a 256-bit number. If the hash is below the target, then a reward is won. If not, the client will increment the number added to the block (completely changing the hash) and tries again. Every 2016 blocks (which should take two weeks if the 10 minute goal is kept perfectly), every Bitcoin client compares the actual time it took to generate the blocks with the two week goal and modifies the target by the percentage difference. This makes the proof-of-work problem more or less difficult.

The work in validating the transaction (block) is rewarded as it is a relatively difficult computational task that requires time, processing cycles, and power consumption. This process of validating transaction is what is referred to as "mining" in the cryptocurrency world. Solving one hash block was originally rewarded with 50 coins. As more blocks became part of the chain, and as one of the methods to avoid inflation and devaluation, the reward halves every 210,000 validated blocks.

One of the main differences between the two major types of cryptocurrencies, Bitcoin and Litecoin, the encryption algorithm utilized in creating the block. Bitcoin utilizes the SHA-256 algorithm, while Litecoin and the majority of other Alt-Coins utilize the Scrypt algorithm. SHA-256 is a more complex encryption algorithm. This requires more processing power to be able to solve the problem in validating a block. As difficulty increased with the number of clients vying for rewards in the early days of Bitcoin, the difficulty factor to keep the transaction times at 10 minutes increased dramatically. This resulted in a processing arms race with miners looking at new methods of solving the cryptography problems faster. Quickly the ability to solve these problems with consumer level CPU's (Central Processing Units) and GPU's (Graphic Processing Units) became unreasonable. Custom built circuitry was developed and spread rapidly amongst the mining community (Peck, 2013).

This processing arms race was the initial impetus behind the creation of Litecoin, the first major alternative to Bitcoin. Litecoin (and most of the other ALT-Coins) began to utilize the Scrypt algorithm in their protocols. Scrypt is a much less complex algorithm then SHA-256. The hash rate cycle for Scrypt based mining has a much shorter time frame. Thus, the machinery performing the mining needs is quicker in trading bit in and out of memory to be worked on. Therefore the dedicated circuits being designed for Bitcoin mining with SHA-256 would not be as effective performing the processing required to mine with the shorter cycle Scrypt encryption (Estes, 2012) (Limer, 2013). The shorter cycle also enables Scrypt based coins to have a shorter target transaction time of approximately 2.5 minutes for validation on the network. Litecoin was officially launched on October 7th, 2011.

Processing Power

As is the case with many other social computing projects, participation is a major factor in the system succeeding. Solving complex cryptography assignments in an effort to validate transactions has a certain transaction cost to those trying to solve the puzzles. Processing power does not come without a cost. With a reward on the line for solving a block, and with the reward becoming more and more valuable as the exchange rate for certain coins exploded, so did the number of people willing to expend processing power to try and earn those rewards.

Hashrate is the unit of measure of processing power for any of the cryptocurrencies. It is the measure of how many hash calculations per second a processor can perform. By extension, the measurement can be added together for a cumulative measure of how much processing power the entire community has put toward the task of validating transactions. With just a few clients attached at the outset, the initial hashrate of the bitcoin network was little more than 7Mhz and a mining client running through a standard central processing unit CPU (Central Processing Unit) of the time could realistically hope to earn a few coins. Shortly into the life of Bitcoin, it became apparent that the repetitive nature of the calculations being performed to solve the hash problems could be done more efficiently with a different processor architecture. CPU's have become very good at very complex tasks and can perform a kaleidoscope of different tasks that are being sent to it.

As specific computing tasks have become more complicated, specifically designed chips have been developed to handle targeted duties. One of the most demanding tasks that processors can handle is the rendering of 3D graphics fast enough for the gaming community. The architecture of higher end GPU (Graphical Processing Unit) graphics cards have become highly evolved for this purpose. The difference between the GPU and the CPU is that the CPU excels at doing complex manipulations to a small set of data, the GPU excels at doing simple manipulations to a large set of data. The GPU designed so that a single instruction works over a large block of data (SIMD/Single Instruction Multiple Data), all of them applying the same operation. Working in blocks of data is more efficient than working with a single cell at a time because there is a much reduced overhead in decoding the instructions. However working in large blocks means there are more parallel working units, so it uses many more transistors to implement a single GPU instruction causing physical size constraint, using more energy, and producing more heat. The CPU is designed to execute a single instruction on a single datum as quickly as possible. Since it only needs to work with a single datum, the number of transistors that is required to implement a single instruction is much less so a CPU can afford to have a larger instruction set, a more complex ALU (Arithmetic Logic Unit), and more sophisticated caching schemes.

Bitcoin miners started to implement graphic cards and GPU's into specially designed arrays realizing an approximate 800 fold increase in processing power. These mining rigs saw the collective power of the bitcoin network rise from 7 Mhash/s on January 1, 2009 to 1.3 Ghash/s on July16, 2010 and to 1.12 Thash/s on May 9, 2011. As of June 2014, the collective hash rate of the Bitcoin network is 1.7 Phash/s (PETA). There were many side effects of this gathering of collective processing power. From the standpoint of the individual miner, the cost for power consumption and the ability to cool these systems rose dramatically. According to a Bitcoin tracking site, blockchain.info, miners were consuming about 1,000 megawatt hours of electricity a day in April of 2013. That is equivalent to half the amount of the electricity needed to power the Large Hadron Collider (Newman, 2014). The cost of graphics cards also skyrocketed (Mathew, 2014) and the availability of the graphics cards became scarce. Many individuals found it impossible to keep up. The solution for the individual was to form mining pools, where multiple individuals could join the power of their individual miner together for a share of the reward earned by the group. For the professional miner, a different answer was needed to curb the rising costs of running the mining rigs. This answer was found through the implementation of ASIC miners.

An ASIC is an application-specific integrated circuit. They are custom-built for specific tasks and can cost tens of thousands of dollars apiece due to the research needed to design, implement and build the chip. This is normally not a process that is in the reach of individuals and left to larger business looking to implement circuitry into mass produced electronics such as cell phones and televisions. With the increase in the exchange price of a bitcoin, though, the prospect of a chip that would be more efficient and consume less overhead in power consumption became very attractive. The first of the ASIC miners became available to the public in the first quarter of 2012 costing thousands of dollars each and in limited availability. Ultimately, ASIC devices are the last great innovation in Bitcoin mining. Once processing is specialized down to the chipset, there is nowhere left to turn that could realize a 100-fold jump in computing power. With the ready availability of ASICs, many started to see the beginning of the end of the gold rush, just as Bitcoin fever reached a fever-pitch.

The arms race of processing power started the evolution of shifting out the amateurs from the professionals in the crypto mining business. It was clear that it would be impossible to compete on any legitimate level without a very large investment in machinery and overhead. This divide was foreseen by many in the mining community and the solution to keep mining returns reachable by the common miner was devised. Scrypt mining was that solution and specifically Litecoin.

Litecoin transactions are performed through Scrypt encryption rather than SHA-25. The time for processing Scrypt attempts is much faster than the time to process SHA-256 transactions. The difference meant that the design of the ASIC chips that could work a SHA-256 problem more efficiently was not as effective at the problem solving of Scrypt transactions. The Scrypt transactions were more efficiently handled by the GPU chipsets that could handle the quicker turnaround in the dataset. Through the creation of Scrypt based coins, many miners were able to continue to use their large arrays of mining rigs of graphic cards they had originally assembled for Bitcoin. However, just as the arms race for processing power escalated with the price of exchange and difficulty of the problems, so has the need for increased processing power escalated in the Litecoin network. As of June 2014 the Litecoin network has a 337.617 Ghash/s hashrate. (bitcoincharts.com) while the next largest Scrypt coin derivative, darkcoin has a network of 103.115 Ghash/s.

The development of ASICs for Scrypt mining has taken longer than for SHA-256. The return on investment was quicker and greater in the Bitcoin markets. The first quarter of 2014 saw the beginning of pre-order being taken by some of the better known and respected ASIC producers for Bitcoin for their Scrypt ASIC chips that are expected to ship in the third quarter of 2014. (Hajdarbegovic, 2014).

The Network

The impetus behind the creation of bitcoin was the perceived need to have a currency that did not rely on a central bank. To accomplish this, it is necessary to implement a network in which no one node has importance over another. A classic case of peer-to-peer networking. There are two main actors on the network, the miners and the wallets. These actors facilitate the passing of the common ledger, or the blockchain. The blockchain is the core of any cryptocurrency, the common record of which coin is owned by which wallet address. Each wallet will become functional on the network when it has fully downloaded the blockchain locally. Every fully validating node keeps a list of available coins on the network. They do not know who has which, only which (wallet, not IP) address (or addresses) they are associated to.

In case an attempt is made to try to spend the same coin twice , the network may temporarily become confused while two conflicting transaction blocks are added to the chain. Some nodes may first see the one transaction, and some others will see the others first. However, the strength of the system is that this disagreement cannot exist for long, and after some time, only one of them will be accepted. A rough overview of the process to mine bitcoins is:

1. New transactions are broadcast to all nodes.
2. Each miner node collects new transactions into a block.
3. Each miner node works on finding a difficult proof-of-work for its block.
4. When a node finds a proof-of-work, it broadcasts the block to all nodes.
5. New bitcoins are successfully collected or "mined" by the receiving node which found the proof-of-work.
6. Nodes accept the block only if all transactions in it are valid and not already spent. As shown against the local blockchain.
7. Nodes express their acceptance of the block by working on creating the next block in the chain, using the hash of the accepted block as the previous hash.
8. Repeat.

Nodes are incentivized to work on extending the longest chain or risk their work being wasted. If two nodes broadcast different versions of the next block simultaneously, some nodes may receive one or the other first. In that case, they work on the first one they received, but save the other branch in case it becomes longer. The tie will be broken when the next proof-of-work is found and one branch becomes longer; the nodes that were working on the other branch will then switch to the longer one. (Barber et al. 2012). New transaction broadcasts do not necessarily need to reach all nodes. As long as they reach many nodes, however, transactions will get into a block quickly. Block broadcasts are also tolerant of dropped messages. If a node does not receive a block, it will request it when it receives the next block and realizes it missed one.

The essential thing in a wallet is not the transactions, but the keys. Each address has an associated public and private key. These private keys never leave the wallet file, and are necessary to spend the coins assigned to a wallets addresses. Because the transactions are tracked by the network, the wallet does not need to be online for a transaction to target it and for that transaction to be accepted on the network. The next time the wallet connects, the client will ask the network for the up-to-date blockchain. During the synchronization that follows, an incoming transaction will be seen, and the client will detect this as an incoming payment.

The broadcast messages of the bitcoin network function as RPC connections over TCP/IP (Transmission Control Protocol/Internet Protocol). Clients listen on port 8332. Bitcoin will also try to connect to IRC (Internet Relay Chat) TCP port 6667 to meet other nodes to connect to. Bitcoin finds peers primarily by connecting to an IRC server (channel #bitcoin on irc.lfnet.org). If a connection to the IRC server cannot be established (like when connecting through TOR), an in-built node list will be used and the nodes will be queried for more node addresses (bitcoinfaq.com). The total address space is 2^160 for unique wallet addresses. This is 1,461,501,637,330,902,918,203,684,832,716,283,019,655,932,542,976 unique addresses.

4. CONCLUSION

The world of cryptocurrencies is broken into several distinct areas of interest. While there are many fine details to focus on, four distinct general areas can be categorized: Trading, Use, Regulation, and Mining. Much attention has been paid to the exchange (Trading) of currencies, the transaction, and the speculation of these coins in a rapidly changing market. Evangelists are pushing for a wider adoption (Use) from companies, countries, and for greater adoption and public ease of use of cryptocurrencies in everyday transactions. Law enforcement and government agencies are learning how to regulate, tax, (Regulation) and investigate transactions made with cryptocurrencies. But at the heart of it all – there has to be a 'coin' driving this whole system. Without the mining aspect of the system, there would be no coin (Mining).

The survivability of any one coin, even Bitcoin, is still very much up to debate and uncertain. The rise in popularity and the continued focus on the system by various sources from governments, entrepreneurs, financial institutions, hardware manufacturers, and especially small business and individuals, does ensure that this concept will survive in some form. While it may not be one specific coin that remains, the infrastructure that allows for the secure transfer of funds from one wallet to another may be the part that evolves to live a much greater life integrated into the existing traditional banking world of today. Through the use of VoIP exchanges between carriers, the idea of long distance calling charges has become relegated to the past. Peer to peer wallet transfers through cryptographic proof of work general legers may someday make the processing fee for bank transactions fade into history as well.

The system of mining that drives Bitcoin, Litecoin, and all other cryptocurrencies has as its heart a series of Computer Science/Information Systems concepts and practices. Raw materials of technology developed for other computing tasks have been put together to form this electronic payment system that is now being used worldwide by millions of people. As CS/ IS educators it is important that this moment in time and opportunity is not lost.

With cryptocurrencies making the jump from the pure technology community into the mainstream, the core technologies of the system can be used to highlight how this information system is not just a "black box" and that there are very important components within that "box". Students can be shown not only practical application of theory, but also the unintended results of utilization of those theories in alternative ways than originally intended. This rare opportunity to introduce to CS/IS students how computer theory can be integrated into other disciplines with examples of real world results should not be missed.

5. REFERENCES

Agius, A (2013, July 17). Three Months as a Litecoin Farmer: Crunching the numbers on virtual currency mining in Australia. Retrieved June 10, 2014 from http://reckoner.com.au/2013/08/im-done-mining-litecoin/

Agius, A. (2013, August 26). I'm Done Mining Litecoin - Reckoner. *RSS*. Retrieved July 3, 2014, from http://reckoner.com.au/2013/08/im-done-mining-litecoin/

Anderson, J., & Rainie, L. (2014, March 11). The More-Hopeful Thesis. *Pew Research Centers Internet American Life Project RSS*. Retrieved May 23, 2014, from http://www.pewinternet.org/2014/03/11/the-more-hopeful-theses/

Barber, S., Boyen, X., Shi, E., & Uzun, E. (2012). *Bitter to Better - How to Make Bitcoin a Better Currency*. Berkeley: Palo Alto Research Center, University of California, Berkeley.

Beanland, C. (2013, April 3). Bitcoin: Is the virtual currency the new gold standard?. The Independent. Retrieved July 11, 2014, from http://www.independent.co.uk/money/spend-save/bitcoin-is-the-virtual-currency-the-new-gold-standard-8558945.html

Benson, C. (2013, December 12). Most Americans Don't Know Bitcoin While Some Guess Xbox. *Bloomberg.com*. Retrieved June 14, 2014, from http://www.bloomberg.com/news/2013-12-12/most-americans-don-t-know-bitcoin-while-some-guess-xbox.html

Block 0?. (n.d.). *Block 0*. Retrieved April 3, 2014, from http://blockexplorer.com/block/000000000019d6689c085ae165831e934ff763ae46a2a6c172b3f1b60a8ce26f

Complete List of Bitcoin Exchanges. (n.d.). *Planet Bitcoin*. Retrieved June 22, 2014, from http://planetbtc.com/complete-list-of-bitcoin-exchanges/

Crypto-Currency Market Capitalizations. (n.d.). *Crypto-Currency Market Capitalizations*. Retrieved June 12, 2014, from https://coinmarketcap.com/

Davis, J. (2011, Oct 10). The Crypto-Currency. The New Yorker, 87, 62-n/a. Retrieved June 21, 2014 from http://search.proquest.com/docview/899209384?accountid=28365

Estes, A. C. (2012, December 6). To Win the Global Bitcoin Arms Race, Crypto Miners Are Building Custom Microchips. *Motherboard*. Retrieved June 5, 2014, from http://motherboard.vice.com/blog/bitcoin-mining-creating-cottage-industry-custom-microchips

Genesis block. (n.d.). - *Bitcoin*. Retrieved June 3, 2014, from https://en.bitcoin.it/wiki/Genesis_block

Gornick, S., & unk, A. (2014, June 14). Bitcoin Difficulty Adjustments. *Bitcoin Difficulty Adjustments*. Retrieved July 3, 2014, from https://docs.google.com/spreadsheet/ccc?key=0AiFMBvXvL2dtdEZkR2J4eU5rS3B4ei1iUmJxSWNlQ0E#gid=0

Greenberg, A (2014, May 14). Bitcoin's nefarious cousin Darkcoin is booming. Retrieved June 10, 2014 from http://www.wired.co.uk/news/archive/2014-05/22/darkcoin-is-booming

Hajdarbegovic, N. (1920, March 14). Scrypt ASIC Race Intensifies, KnCMiner Scores $2m in Preorders. *CoinDesk RSS*. Retrieved July 3, 2014, from http://www.coindesk.com/scrypt-asic-race-intensifies-knc-scores-2m-preorders/

Harpaz, J. (2014, March 25). IRS Says Bitcoin Is Property, Not Currency. *Forbes*. Retrieved April 15, 2014, from http://www.forbes.com/sites/joeharpaz/2014/03/25/update-irs-says-bitcoin-is-property-not-currency/

How are new bitcoins created?. (n.d.). *Bitcoin FAQ*. Retrieved November 14, 2013, from http://bitcoinfaq.com/

How does Bitcoin work?. (2013, April 11). *The Economist*. Retrieved November 14, 2013, from http://www.economist.com/blogs/economist-explains/2013/04/economist-explains-how-does-bitcoin-work

IRS Virtual Currency Guidance : Virtual Currency Is Treated as Property for U.S. Federal Tax Purposes; General Rules for Property Transactions Apply. (2014, March 25). *IRS Virtual Currency Guidance : Virtual Currency Is Treated as Property for U.S. Federal Tax Purposes; General Rules for Property Transactions Apply*. Retrieved April 15, 2014, from http://www.irs.gov/uac/Newsroom/IRS-Virtual-Currency-Guidance

Limer, E. (2013, April 15). Digital Drills: The Monster Machines that Mine Bitcoin. *Gizmodo*. Retrieved July 3, 2014, from http://gizmodo.com/5994446/digital-drills-the-monster-machines-that-mine-bitcoin

Litecoin statistics. (n.d.). - *Price, Blocks Count, Difficulty, Hashrate, Value*. Retrieved June 14, 2014, from http://bitinfocharts.com/litecoin/

Mathew, J. (2014, February 15). Increased Demand from Litecoin Miners Boosts AMD Graphics Card Prices. *International Business Times RSS*. Retrieved March 11, 2014, from http://www.ibtimes.co.uk/increased-demand-litecoin-miners-boosts-amd-graphics-card-prices-1436542

McArdle, L. (2001). Beyond encryption. Software Development, 9(1), 73-74. Retrieved June 21, 2014 from http://search.proquest.com/docview/222191775?accountid=28365

McFarlane, G. (2014, June 26). The 6 Most-Traded Currencies and Why They're So Popular. *Investopedia*. Retrieved June 27, 2014, from http://www.investopedia.com/articles/general/022814/rewrite-6-mosttraded-currencies-and-why-theyre-so-popular.asp

McLuhan, M. (2011). *The Gutenberg galaxy: the making of typographic man*. Toronto: University of Toronto Press, Scholarly Publishing Division. (Original work published 1962)

Morris, D. (2013, December 24). Beyond bitcoin: Inside the cryptocurrency ecosystem. *Fortune*. Retrieved January 11, 2014, from http://fortune.com/2013/12/24/beyond-bitcoin-inside-the-cryptocurrency-ecosystem/

Nakamoto, S. (2009). *Bitcoin: A Peer-to-Peer Electronic Cash System*. Web: www.bitcoin.org.

Newman, L. H. (2014, June 2). Bitcoin Mining Has An Absurd Environmental Impact. *Gizmodo*. Retrieved July 3, 2014, from http://gizmodo.com/5994626/bitcoin-mining-has-an-absurd-environmental-impact

Nicklaus, D. (2014, March 1). Volatility will keep bitcoin on the fringes of finance: Business. *stltoday.com*. Retrieved June 9, 2014, from http://www.stltoday.com/business/columns/david-nicklaus/volatility-will-keep-bitcoin-on-the-fringes-of-finance/article_935c5c9a-33fb-5790-948e-f274fa9e4ecc.html

Nielsen, M. (2013, January 6). How the Bitcoin protocol actually works. *DDI*. Retrieved June 30, 2014, from http://www.michaelnielsen.org/ddi/how-the-bitcoin-protocol-actually-works/

Peck, M. (2013, May 12). Bitcoin: The Cryptoanarchists' Answer to Cash. - *IEEE Spectrum*. Retrieved March 27, 2014, from http://spectrum.ieee.org/computing/software/bitcoin-the-cryptoanarchists-answer-to-cash

Peck, M. (2013, May 6). The Bitcoin Arms Race Is On!. - *IEEE Spectrum*. Retrieved July 2, 2014, from http://spectrum.ieee.org/computing/networks/the-bitcoin-arms-race-is-on

Schwartz, J. (2014, April 5). My bitcoin befuddlement. *The New York Times*. Retrieved May 23, 2014, from http://www.nytimes.com/2014/04/06/business/mutfund/my-bitcoin-befuddlement.html

Spahn, H. (2001). *From gold to euro: on monetary theory and the history of currency systems*. Berlin: Springer.

Spaven, E. (2014, January 29). Everything You Need to Know About the New York Hearings on Bitcoin. *CoinDesk RSS*. Retrieved June 3, 2014, from http://www.coindesk.com/everything-you-need-to-know-new-york-hearings-bitcoin/

Vance, A., & Stone, B. (2014, January 9). The Bitcoin-Mining Arms Race Heats Up. *Bloomberg Business Week*. Retrieved May 21, 2014, from http://www.businessweek.com/articles/2014-01-09/bitcoin-mining-chips-gear-computing-groups-competition-heats-up

Why a GPU mines faster than a CPU. (n.d.). - *Bitcoin*. Retrieved January 3, 2014, from https://en.bitcoin.it/wiki/Why_a_GPU_mines_faster_than_a_CPU#A_CPU_is_an_executive

Wile, R. (2014, January 23). The Winklevoss Twins Will Headline New York State's Bitcoin Hearings. *Business Insider*. Retrieved February 7, 2014, from http://www.businessinsider.com/new-york-bitcoin-hearing-info-2014-1

Scrypt ASIC race archives - CryptoCoinsNews. (n.d.). *CryptoCoinsNews*. Retrieved June 2, 2014, from http://www.cryptocoinsnews.com/tag/scrypt-asic-race

ytd charts from Bitfinex . (n.d.). *ytd charts from Bitfinex* . Retrieved July 3, 2014, from http://www.ltc-charts.com/period-charts.php?period=ytd&resolution=day&pair=ltc-usd&market=bitfinex

Empowering Freshmen with Technology Skills: Wireless Routers

William VanderClock
WVanderClock@Bentley.edu
Bentley University
Waltham, MA 02452, USA

Abstract

Most freshmen taking required, introductory information systems courses do not understand why they are required to take such courses and can't imagine that they will learn anything they don't already know. This paper presents an exercise that will excite and enthuse students about their computers and Information Systems in general. Every freshman is familiar with wireless network connections having used them with both their computers and their phones. The setup of those wireless networks however is somewhat of a mystery and considered far too complex to deal with by most students. This paper outlines a strategy for demystifying the technology and involving students in hands-on learning. By actually setting up a wireless router students gain confidence in their computer skills and become interested in learning more about information systems. This paper describes the process used to gain their interest and includes a handbook that can be used with students everywhere.

Keywords: wireless networks, routers, TCP/IP, teaching the introductory course

1. INTRODUCTION

As technology becomes more and more part of our world many schools like Bentley require students to take an introductory course in information systems. In most cases there is no assessment of the student's technology skills so that a typical class has a broad range of ability, interest, and technology skills among the students. Students typically do not want to take these required courses because they often do not have an interest in technology. Their world has always included computers and most believe they know enough from high school or personal experience to succeed in both their personal and professional lives. As teachers we are faced with the difficulty of even getting their attention no less motivating them to learn the fundamentals of our discipline, information systems.

Most students, although they know little of how networks operate, are very interested in being connected. Their experience with wireless networks is a mix of success and failure.

1. They love to be connected and as cost conscience consumers are always looking for a "free" connection that will not impact the cell phone bill.
2. Speed is very important to them and often a Wi-Fi connection is much faster than their cell carrier's data connection.
3. Although most understand the concept of a wireless password to get on a particular network, many have been frustrated by failure to connect even with the correct password.
4. Streaming (music or video) is an important part of their lives. Lack of knowledge often leads to more frustration as videos pixilate or refuse to play.

This paper presents one way to awaken student's attention and capture their interest. Most students find this a fun and empowering exercise that can change their view of information systems. Some have even pointed to it as the reason they started thinking about selecting information systems as their major.

Bentley University has one of the longest running portable computer programs in the country. All students have been required to have a school supplied laptop computer running Microsoft Windows since 1984. The author has approached this paper with the assumption that most students have access to a portable computer for the introductory course and likely have some form of smart phone. The instructions are written for the Microsoft Windows environment but can easily be changed to accommodate Apple machines. Students are broken into groups of three or four and each group must have at least one laptop and one smart phone among the three or four devices in the group. Although the exercise can be done with three laptops, using a smart phone as one of the devices is a real plus from the student perspective. A physical router is also required for each group. Although it is easier for the instructor if all the routers are identical, a variety of routers could be used with the understanding that each manufacturer builds their menus a little differently. This exercise was so successful we currently use it in all sections of our introductory course and continue to receive very positive feedback from students about it.

The paper presents the material in the form of a handbook. The *IT101 Wireless Router Lab* gives students a step by step instruction set for building a wireless network. There are 20 questions included in the handbook and we use the answers to the questions as proof of learning. As you will see in the handbook we introduce students to on-line collaboration by requiring the document to be done in the form of a Google Doc. This gives the instructor the ability to see which student has done what questions through the revision history. An actual copy of the current handbook is located in the appendices.

2. IT101 WIRELESS ROUTER LAB

This lab exercise is designed to allow your students to learn to create a wireless network, and connect computers to it both with and without encryption and interact with networking tools in the Windows operating system. There is an actual copy of the document we give students in the appendices of this paper. There is also an instructor's guide with specifics for instructors running the Lab in the appendices. The Lab is best done in groups of 3 students but can be done with 4.

What they need to know before starting

How to connect your computer to a wireless network
How to use a web browser
How to determine a computer or mobile device's MAC address and IP Address
How to recognize a router, and what a router does
How to use Google Docs to create, edit, and share a document
How to take a screen shot on your computer and mobile device

Required Hardware

1 Wireless Router
1 computer equipped with wireless networking capabilities
1 mobile device equipped with wireless networking capabilities
1 computer equipped with an Ethernet adaptor (any wireless should be turned off)
2 Ethernet cables
1 USB flash drive
1 wired Internet connection

Software

Windows 7 on at least one laptop (other operating systems work but the directions are different from what is presented here.) If you have a computer that is not running Windows 7 in a group, please use it for computer #1 since that machine is only using a browser.
A Web browser (Internet Explorer, Firefox, Safari, Chrome, etc. all work equally well)
Gmail accounts for all group members

Lab Report

Each group will collaborate to complete a lab report as a Google Doc containing several screen shots and answers to questions that appear within the instructions. Have the students decide which questions each person will work on for the lab report. In many cases they will be creating screen shots or taking digital photographs. Have them take notes as they do the Lab and upload the notes and images to the Google Doc either as they go along, or shortly after they complete the exercise. They should NOT write their part of the lab report in Microsoft Word and paste it into Google Docs all at once. Each member of the group should contribute to the Lab report. The instructor can identify what was added to the Google Document by each member of the group using the Revision History tool. Note that they cannot take too many screen shots.

Group members and roles

There should be three people in each group, each managing a different device. The roles are:

Role #1: This person is responsible for configuring the router using a personal computer.

Role #2: This person will connect a personal computer wirelessly to the network. There should not be ANY Ethernet cables connected to this computer.

Role #3: This person will connect a mobile device (smart phone or tablet) wirelessly to the network.

Create a wireless network!

Start by having one person in each group create a Google Doc for the group's lab report, and invite the other group members and the instructor as collaborators. They will need the Google ID's for each person in the group, and the instructor. All group members should open Google Drive and access the lab report document so that each person can edit it at the same time as they complete the exercise.

Have them completely power down Computer #1 (the "wired" machine, to which they will connect the router with an Ethernet cable).

Have them identify the ports on the back of the router. There should be 4 LAN ports (black interiors), one WAN port (yellow interior) and possibly one USB port.

Connect the wired computer (Computer #1) to the router making sure the cable connects to one of the 4 LAN ports (black ports).

Connect the WAN port (yellow port) on the router to a working Internet connection using an Ethernet cable.

Power up the router by plugging the power brick into an outlet and the router. If nothing happens look for a power button on the router.

There are LED lights on the front of the router to give you the status of the router. Watch the icons on the router as it boots.

When lights are lit on the router power up the wire connected computer and log into Windows.

Configure the router on the wired computer

Every router has a set of default settings that can be looked up on the Internet. These include a default address, a user name and a password. It is best to look these up and have them ready for the students.

Have them connect to the router's built-in Web page by placing the router's default address into a Web browser on the wired computer. Once they have connected to the router's Web page the rest is just a matter of navigating through the router's menus making changes and testing the changes.

The first change you want them to make is to set a new administrative password. Challenge them to use their knowledge of good passwords to come up with a group password that will keep their router settings safe from the other groups in the room.

Set the SSID for the Network on the router

Next have each group select an SSID for their network. We had some trouble with groups selecting inappropriate names so we now give them some guidance with this instruction: "Create an SSID for your group by using the first three letters of the first name of each person in your group. (For example, bilmardou for Bill, Mark, Doug). Use this nine-character string as the SSID. Type it in entirely in lower case. NOTE: The SSID is case sensitive just like a password.

Connect a computer or mobile device to your wireless network

Most students are familiar with connecting both computers and mobile devices to unprotected wireless networks so this step should be easy. **In Windows 7, the first time you connect to a network, sometimes you are asked to classify its location type as home, work, or public. When you are connected to a public location, Windows 7, if told it is a public location, disables all network and sharing to protect your information. You can change what kind of connection it is at any time by modifying the settings for that connection. In this Lab the students are building the equivalent of a work network and should identify as such if asked. Windows may not display the Set Network Location dialog box immediately. They can continue with the exercise regardless of whether or not they set the network's location.**

Connecting a mobile device may require them to go out to the Internet on a connected computer to look up how to do it on their particular device. Have them make sure that they are connected to the correct network and that they have Internet access.

Find the IP and MAC addresses of your computer and mobile device
Most students are not familiar with these addresses and the number of different connections on some laptops can make this really confusing. This is an opportunity to familiarize the students with the Command Prompt window in Windows and to discover where these addresses are listed on their mobile device. The general instructions for finding these addresses are:

Your computer or mobile device's IP address consists of 4 numbers separated by periods. It may also be called the IPv4 address. If your device has an IP address it verifies that it is connected to a network. The MAC address (sometimes called the *physical address)* consists of 6 sets of two digits separated by dashes or colons. It is a number that uniquely identifies your device. To find this information in Windows:

Click the Start button in the lower left corner and select "All Programs".

Select "Accessories" and then "Command Prompt".

In the command window, type ipconfig /all and press <ENTER>. (make sure there is a space between ipconfig and the /). Issuing the ipconfig /all command generates several screens of information. Many computers have several MAC or physical addresses associated with it, so make sure you are looking at the correct one for your machine's connection. When looking at the results of the ipconfig /all command, Computer #1's IP address (IPv4) and physical (MAC) address are located under *Ethernet adapter Local Area Connection*. Computer #2's IP address is located under*Wireless LAN Adapter Wireless Network Connection.* To find your IP and MAC address on your mobile device:

On an iOS device, from the Settings app, tap Wifi, locate the network to which you're connected, and tap the arrow near the network name to reveal the IP address. Tap Settings, General, About to find your MAC address.
On an Android device, tap Settings, Device Settings, Status to view your IP and MAC addresses

Use a search engine to find more detailed instructions to find your IP or MAC address on your device if necessary.

See which devices are connected to the network
An important tool for checking on connections is the Attached Devices List (it may have a different name depending upon the router). The Attached Devices list (on the router menu) identifies the computers connected to the router by their IP addresses (and specifies whether they are connected via a wired or wireless connection). On the wired computer, click the menu choice Attached Devices on the router's menu list to see a list of what computers are connected to it. Remind students that they can use the Attached Devices menu choice on the router at any time to check and see who is actually connected to their router. Important note: You cannot see MAC addresses or IP addresses for other computers in the black Windows Command Prompt box. Only that computer's information will show there. The router sees all of the computers and the Attached Devices menu option on the router will show everyone attached to that router.

Stop broadcasting the network's SSID
The next security step is to turn off the broadcast of the SSID. When this is done the name of the network no longer shows up on the list of available networks unless a setting has been added. The box to broadcast or not is usually on the wireless settings screen on the router. This will disconnect the wireless devices and wireless laptops from the network. This is the first spot where students who are not careful can run into a large amount of frustration trying to get reconnected. There seems to always be one group that makes the wrong change and shuts off wireless altogether. Here are the instructions we use to get the laptops back on:

Left-click the wireless icon in the bottom right-corner of the task bar to see a list of available networks and indicate if you are connected to any of them. (If you are connected to another network please click disconnect)

At the bottom; click on "Open Network and Sharing Center".

On the left side of the Network and Sharing Center screen click on "Manage Wireless Networks".You should see your network on the list.

If your network is on the list, right click it and click properties. You will get a list of three check-off boxes for Auto Connect, Preferred Network and "Connect even if the network is not broadcasting its name". You should check the first and last ones but not the middle one. Also note the Security tab which you will be coming back to when we do the security part of this exercise.

If not click "add" at the top, click "Manually create a network profile" and add the information about your network. You are required to select a security choice and at this point you have none so select the "open" option. Note the check box for automatic start (if checked your computer will automatically connect if it sees this network) and the one for "Connect even if the network is not broadcasting" which needs to be checked if you want to see your network when the router is not broadcasting the SSID. Click next and then close.
Note: You may find that your computer has added a 2 next to the SSID on your computer. The SSID has not changed, the 2 is not part of the name. This is how Windows avoids confusion if an SSID has been added to the list when there is already one there with that SSID. You can always delete the old one.
To connect your mobile device to a network with a hidden SSID:

On an iOS device, tap Settings / WiFi Networks / Other, and enter the network information.

On an Android device, tap Settings, Wi-Fi, Add Wi-Fi network, and enter the network information.

Use a search engine to find more detailed instructions to find your IP or MAC address on your device if necessary. After they have completed one of the two options above they should get their network on the list of available networks and they should be able to connect. Have them verify that they are connected. If they cannot connect, the settings for that network do not match the settings for the network on the router. The settings must match for the computer or mobile device to connect.

Add encryption to the network
Encrypting the network traffic is a very important step for the students to understand. Many do not realize that with an unprotected network (coffee shops, airports, etc.) everything they type in travels through the air in plain text. Almost anyone can capture and look at whatever passwords are being sent. Encryption has changed over the years and the age of a particular device determines which of the standard three types found on most routers can be done by the device. WEP is the oldest and the weakest. We recommend using WPA2 which is the newest although it has also been broken. Older routers require a hex string but most modern routers will take a word, phrase or hex string. Have them turn on the encryption (which will disconnect the wireless folks again) and build a passphrase to allow the wireless devices to reconnect. The important thing to emphasize here is that whatever security is set on the router must be matched exactly on the device trying to connect. They already have the skills in Windows from the previous section to change the security setting on a Windows machine. Fortunately most other devices make it even easier to connect by self-discovering the security settings and just requiring the passphrase to connect. We tell them:
"Refresh your list of wireless networks on the wireless device. Choose your SSID from the list. When you do, it will prompt you for the key (passphrase) and you must type it in correctly. Remember, the key is case sensitive! If you have trouble connecting use the same process you used earlier to modify each wireless device's settings for your network. You will need to add the encryption settings on the Security tab of the Properties window for your SSID. Again, if the settings on your computer match the settings on the router you will connect. If the settings do not match there is no way you can connect. Note: If neither computer can connect to the network, reconfigure the router using computer #1 to broadcast its SSID. See if that helps. Make sure that on computers 2 & 3, Security Type is set to WPA2-Personal and that Encryption Type is set to AES. The passphrase is case sensitive so make sure that is correct too!"

Allow network access based on MAC address
This section is where students seem to have more trouble than anywhere else. Almost all

routers have the ability to filter connections based upon MAC address. When a device wants to connect the router goes to its list of valid MAC addresses and will only let devices on the list connect. This involves building the list turning the filtering on. It will most likely be located in the router menus under advanced wireless settings or advanced security. The hard part on laptops is finding the correct MAC address. Phones ad tablets generally only have one MAC address making it somewhat easier. If they were careful in the section about finding the addresses and wrote them down correctly they should have an easy time with this.

Manage your wireless networks
In this section we take the students to their history list of networks rather than the currently available networks. Most are not aware of this historical list and their ability to clear out any of the networks on the list. Most mobile devices have a similar list but the iPhone does not.

ACCESS NETWORKED STORAGE
If the router has a USB port then it has the ability to provide a common storage area for everyone on the network. We put a music video on a flash drive in the router and students discover that they can connect and play the video on multiple machines. The most common error here is leaving the MAC address filter on from the previous section and finding one of the devices cannot get to the storage because it can't get on the network.

Running out of time? Save your Configuration (OPTIONAL)
Most routers give the user the ability to save the router settings in a file on a computer. Our first attempts at this Lab ran long and so we used this as a way to be able to pick up where we left off if it could not be completed in one class meeting. Students always try to open the file once it is on their laptop so you need to explain that the file can only be used by a router and the laptop is just holding it to be placed on a router.

Clean up after yourself
These routers now have all kinds of passwords, passphrases, encryption and other settings. It is very important that each router be reset back to the factory defaults. There are 2 ways to do this; through the menu system or with a physical button hidden on the router. Using the menu system is the easiest and if you can get the group to do that the router is all set for its next group. If not the hidden button that requires a paperclip to push can be used but every company does the button a little differently requiring holding the button down while the router is plugged in for a very specific number of seconds.

Questions
These are the questions we give the students to complete as part of the Lab.

1. Why is it critical that the router be on and connected to the computer used to set it up before you turn the computer on? (hint – from where does the computer get it's IP address?)
2. What does the administrative password protect?
3. What SSID did your group use? What does an SSID tell you?
4. Where do the names of available wireless networks come from? How do you know from examining the list of names of available wireless networks whether or not a network is open or uses encryption?
5. When might it be preferable to connect to the Internet using a Wi-Fi connection rather than a cellular connection on your mobile device?
6. Enter the information from the IPv4 and MAC address table below in your lab report.

Device	IPv4 Address	MAC Address
Computer #1		
Computer #2		
Mobile		

Why should you look for Computer 1's IP address under the Ethernet Adapter Local Area Connection, and Computer 2's IP address under the Wireless LAN Network Connection section of the ipconfig results?

7. In "Attached Devices" which devices are associated with the IP addresses listed?
8. Is anyone else connected to your network? (How do you know?)

9. Once you disconnect computer #2 and your mobile device from your wireless network, open a web browser and visit a web site such as google.com. Do you have Internet connectivity? If so, to which network are you connected? If not, why did you lose connectivity?
10. How do networks that don't broadcast their SSIDs appear in the "Connect to a Network" dialog box?
11. Consider a network that doesn't have encryption and also doesn't broadcast its SSID. Do those two things make your network more secure or less secure? (explain)
12. What does adding WPA2 encryption do for your network?
13. Name three <u>different</u> steps you took to secure your network so far.
14. Can you add encryption without using a passphrase?
15. Why would you want to add this level of security (MAC address filtering) to your network? (please explain)
16. How can you configure computer #2 to remove or forget the name of the network you created in this exercise? (Write the steps to accomplish this on computer #2.) Take a screenshot showing the names that appear on the list of Wi-Fi networks stored on computer #2. Where did they come from?
17. How can you configure your mobile device to remove or forget the name of the network you created in this exercise? (Write the steps to accomplish this on your mobile device.) Take a screenshot showing the names that appear on the list of Wi-Fi networks stored on your mobile device. Where did they come from?
18. What could you use this "Network Storage" for on your network at home? (Each group member should answer the last two questions individually with their name on their answer in the report.)
19. What part of this lab exercise gave your group the most trouble and why?
20. What did you learn from this exercise? (Each group member should answer this question individually with their name on their answer in the report.)

3. LEARNING OUTCOMES

This exercise has been run with 30 sections of Bentley's Introduction to IT course for 4 years. Although we have not specifically tested for results from the exercise the number of times the Wireless Router Lab is mentioned positively in teacher evaluations is significant. We are also hearing from graduates that this exercise was helpful to them in their initial work environment. It would be to our benefit to do some research into how it is impacting their views of Information Technology.

4. CONCLUSIONS

This paper provides a technique to motivate freshmen to learn computer technology by requiring them to build a protected wireless network. The intent is to awaken an interest in the computer discipline by providing the tools and knowledge to help them understand something they use daily but do not understand or assume is too difficult. Once the network is built the students layer various security options on the wireless network. It is always important to expose students to new ideas and knowledge that allows them to make better use of the technology around them. This networking exercise will enable and motivate students to take another look at information systems as a course of study. It will also give them self confidence in dealing with their home networks when they go home.

5. REFERENCES

Vladimir Bychkovsky, Bret Hull, Allen Miu, Hari Balakrishnan, and Samuel Madden (2006) MIT Computer Science and Artificial Intelligence Laboratory *A Measurement Study of Vehicular Internet Access Using In Situ Wi-Fi Networks* http://cartel.csail.mit.edu

Kipp Jones, Ling Liu (2006) Division of Computer Science and Systems Georgia Institute of Technology, Atlanta, GA *What Where Wi: An Analysis of Millions of Wi-Fi Access Points*, USA {kippster, lingliu}@cc.gatech.edu

Bouchaib Bahli, Younes Benslimane, (2004) Information Management & Computer Security, Vol. 12 Iss: 3, pp.245 – 254 *"An exploration of wireless computing risks: Development of a risk taxonomy"*

Gary G. Berg, Michelle S. Freeman, and Kent N. Schneider The CPA Journal (2008) *Analyzing the TJ Maxx Data Security Fiasco Lessons for Auditors*

C. Bernardos, A. García Martínez, C. Durán *(2009) COMPUTER NETWORKING TEACHING EXPERIENCES USING COTS ROUTERS AND VIRTUAL ENVIRONMENTS: THE UC3M LABORATORY, ICERI2009 Proceedings, pp. 7151-7158.*

Smith, Shannon D., Gail Salaway, and Judith Borreson Caruso. *"The ECAR study of undergraduate students and information technology, 2009."* (2009): 1-130.

Buzzetto-More, Nicole A., and Retta Sweat-Guy. *"The technology ownership and information acquisition habits of HBCU freshmen."* Interdisciplinary Journal of Information, Knowledge, and Management 2.1 (2007): 59-72.

NAS Insights. (2006). *Gen Y, The millennials. Ready or not here they come.*, http://www.nasrecruitment.com/. Retrieved at July 12, 2009, from the website temoa : Open Educational Resources (OER) Portal at http://www.temoa.info/node/22174

Appendices

IT101 Wireless Router Lab

In this lab exercise you will learn to create a wireless network, and connect computers to it with and without encryption and interact with networking tools in the Windows 7 operating system. These instructions assume that you are using computers that have been maintained to the Bentley standards. That means weekly scans for both virus and spyware activity, no file sharing and safe Web surfing.
This Lab requires the group to follow the instructions step by step. Do not skip or ignore any steps or you will have problems later in the Lab. Read the steps carefully as you do them.
The questions found throughout this Lab report are very likely to appear on the Final Exam for IT101 so make sure you know the answers by the time you have finished the Lab.

WHAT YOU NEED TO KNOW BEFORE STARTING

- How to connect your computer to a wireless network
- How to use a web browser
- How to determine a computer or mobile device's MAC address and IP Address
- How to recognize a router, and what a router does
- How to use Google Docs to create, edit, and share a document
- How to take a screen shot on your computer and mobile device

HARDWARE

- 1 Netgear Dual Band Gigabit Wireless Router
- 1 computer equipped with wireless networking capabilities
- 1 mobile device equipped with wireless networking capabilities
- 1 computer equipped with an Ethernet adaptor (any wireless should be turned off)
- 2 Ethernet cables – one blue and one yellow
- 1 USB flash drive

SOFTWARE

- Windows 7 on your laptop (other operating systems work but the directions are different from what is presented here.) If you have a computer that is not running Windows 7 in your group, please use it for computer #1 since that machine is only using a browser.
- A Web browser (Internet Explorer, Firefox, Safari, Chrome, etc. all work equally well)
- Gmail accounts for **all** group members

Lab Report

Your group will collaborate to complete a lab report as a Google Doc containing several screen shots and answers to questions that appear within these instructions. Decide among yourselves which questions each person will work on for the lab report. In many cases you will be creating screen shots or taking digital photographs. Take notes as you go along on this lab report, and upload your notes and images to the Google Doc either as you go along, or shortly after you complete the exercise.
You should NOT write your part of the lab report in Microsoft Word and paste it into Google Docs all at once. Each member of the group should contribute to the Lab report. Your instructor can identify what

was added to the Google Document by each member of the group so try to distribute the work evenly. Note that you cannot take too many screen shots. When in doubt, take a screenshot. That screenshot might save your group's Lab report!

Note: To take a screen shot and insert into a Google Document, you will need to save the screen shot in an image file format (such as JPG or PNG) on your computer, and then use Insert Picture to locate the file and add it to your Google document.

> *Questions for your group to answer in your lab report appear within the lab procedures. Please note the answers to each question or take the required screen shots and/or pictures before moving on to the next step.*

GROUP MEMBERS AND ROLES

There should be three people in your group, each managing a different PC. Decide which of you will take on each of these roles:

- Role #1: This person is responsible for configuring the router using a personal computer (referred to as Computer #1 in the steps below).
- Role #2: This person will connect a personal computer (referred to as Computer #2 in the steps below) wirelessly to the network. There should not be ANY Ethernet cables connected to this computer.
- Role #3 : This person will connect a mobile device wirelessly to the network.

The instructions identify each role by the corresponding number (1, 2, or 3). Be sure you know which role you are taking on before you continue. A 4th person can follow the same steps as Role #3 on a personal computer if you need to have 4 people in a group.

Your group will work together to build a wireless network and answers the questions that appear within these instructions. Your Lab Report is worth 5% of your course grade for IT101 so make sure you pay attention to all the details.

create your wireless network!

Create the Google document for your lab report

One person in each group should create a Google Doc for your group's lab report, and invite the other group members and the instructor as collaborators. You will need the Google ID's for each person in your group, and your instructor. All group members should open Google Drive and access the lab report document so that each person can edit it at the same time as you complete the exercise. Please create the Google document right now if you have not already done so.

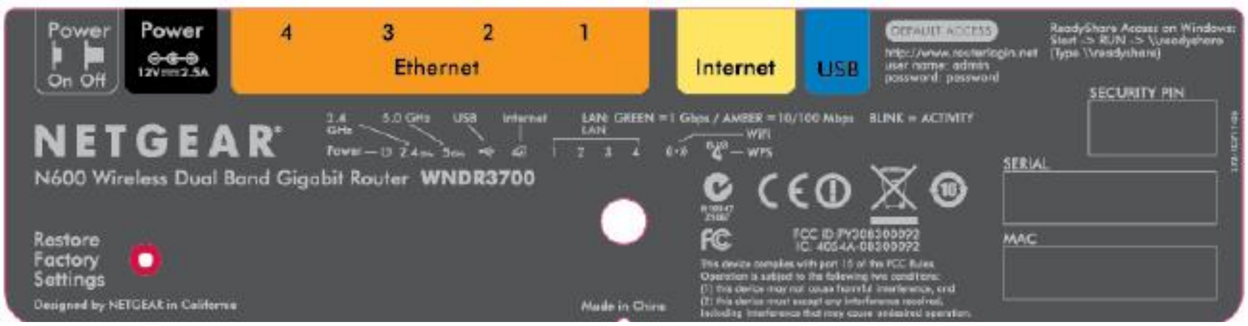
- Download the Lab Report Template from Blackboard. Create a new Google Doc, and then import the template into Google Docs.
- **Enter the names of everyone in your group at the top of the document.**
- **Rename the document to S14IT101XXX Router Lab – LastName1, LastName2, LastName3 where XXX is your section number, and each group member's last name is given.**

CONNECT THE ROUTER to the wired computer

Your first task is to get the router up and running. It takes several minutes for the router to boot and then the wired computer connected to it has to boot which takes forever. Please get the router booted up and running as quickly as you can and then take your time to do the rest.

1. Completely power down Computer #1 (the "wired" machine, to which you will connect the router with an Ethernet cable).
2. Identify the ports on the back of the router. Starting at the bottom just above the power button there should be a place to plug in the power cord, 4 LAN ports (black interiors), one WAN port (yellow interior) and one USB port.
3. Connect the wired computer (Computer #1) to the router making sure the cable connects to one of the 4 LAN ports (black ports). (a blue cable would be good for this)
4. Connect the WAN port (yellow port) on the router to a working Internet connection using an Ethernet cable. (a yellow cable would be good for this)

There is a guide to the ports on the bottom of the router:



Back Panel

The rear panel of the WNDR3700 router contains the items in the list that follows the figure.

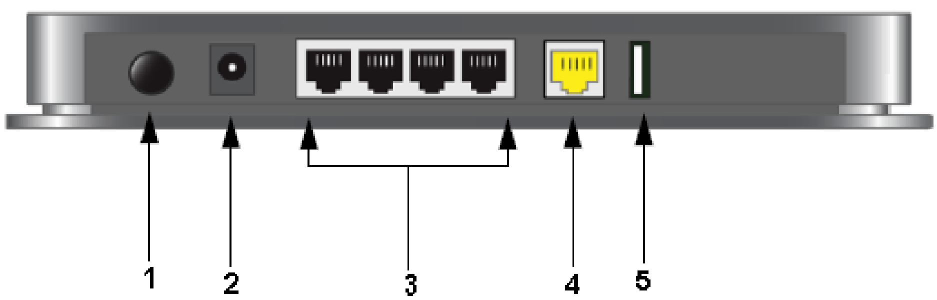


Figure 3

The back of the N600 wireless gigabit router includes:

1. A Power On/Off button.
2. An AC power adapter outlet.
3. Four local (LAN) 10/100/1000 Mbps Ethernet ports for connecting the router to local computers.
4. An Internet (WAN) 10/100/1000 Mbps Ethernet port for connecting the router to a cable or DSL modem.
5. A USB 2.0 port (backward compatible to USB 1.0/1.1) for attaching a USB storage device.

5. Power up the router by plugging the power brick into an outlet and the router. If nothing happens press the power button at the bottom of the back panel.
6. There are LED lights on the front of the router to give you the status of the router. Watch the icons on the router as it boots. The top led is just to show that the power is on. It is yellow when the router is first turned on and changes to green after the router is booted and operational.
7. The next 2 lights are for the two wireless radios in this router, green for the 2.4 GHz radio and blue for the 5 GHz radio (Most older routers only have 1 radio for wireless. Many newer routers have 2 like this router). Both of these lights will light but take a full minute after the router is powered up to appear.
8. The 4th light is for a USB storage device that can be connected to the router. It will be lit if a memory stick is plugged into the back of the router.
9. The next light is the Internet light. As long as you have a good Ethernet wire connection to a working Internet port this light will light green. If this light is not lit you need to check your Ethernet cord and maybe try another network port on the table. **without this connection no one in your group will have Internet access while connected to your network**
IF YOU DO NOT HAVE 4 or 5 (not 3) LIGHTS LIT AT THIS POINT, NOTHING IS GOING TO WORK. PLEASE GET SOME HELP IF YOU DO NOT HAVE 4 LIGHTS LIT ON YOUR ROUTER NOW!

10. When you have the 4 or 5 lights lit on the router power **up the wire connected computer** and log into Windows. The 6th position light on the router should be on for a total of 5 or 6 lit lights. The current HP computers light this light even if they are not booted because the Ethernet port has power even when the computer is off.

> *1. Why is it critical that the router be on and connected to the computer used to set it up before you turn the computer on? (hint – from where does the computer get it's IP address?)*

Configure the router on the wired computer

11. Open a web browser on the wired computer.
12. In the browser's address bar, type the IP address **192.168.1.1** and press <ENTER>.
13. You will be prompted for a username and password. For the Netgear WNDR3700 the username is: **admin** and the password is: **password** . These are the default username and password for this router. The default settings for any router can be found on the Internet.
14. You will get a Netgear screen of one kind or another. Regardless of what screen it is, **we are not making changes here yet**. There is a very important task to do first, change the router's password. On the left side of the screen is a menu list. It is subdivided into groups because some of the menu items are the same but apply to different parts of the router. Scroll down (there are three different sections to this Web page and each has its own scroll bar. Be careful where you scroll) to the 4th group labeled "Maintenance". **In that group click on "Set Password".**
15. Change the administrative password to something that you write down on this sheet. Use all of your password knowledge to build a good password. Do not use your Bentley password; others in

the group may use the password during the exercise. Keep in mind that this password has nothing to do with the wireless connection. It is the password that allows anyone to make changes to EVERYTHING on your router. Only the person authorized to make changes to how the router works should have access to this password. It has nothing to do with who can access the network!

2. What does the administrative password protect?

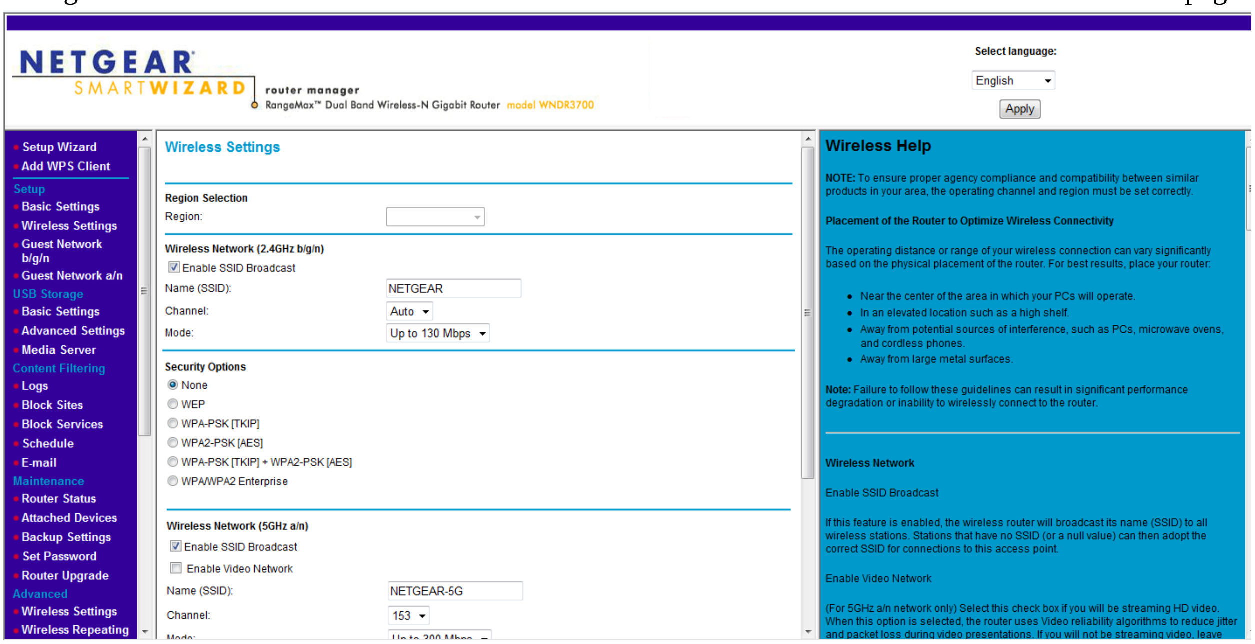
16. The router immediately will prompt you to log in again. You will need to use the new password this time and it will take you right back to the "Set Password" screen.

17. Login using your new password and **ignore any questions on the screen**.

PLEASE NOTE: changes you make to the router do not take place instantly. **The router requires some time to process and actually make the changes.** Although the screen may come back quickly it will still be a minute before the changes you made will take effect. Take a breath and give the router a chance to do what you are asking!

Set the SSID For your Network on the wired computer

18. On the far left menu, click on "**Wireless Settings**" in the Setup group to get the first wireless settings page.



If any of the router screens are left untouched for more than 2 minutes the login screen will pop-up when you finally do try to make a change. This is perfectly normal and should not cause any problem as long as you know the router's administrative password.

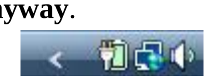
19. There are 2 wireless radios on this router, so there are two places for each of the setup items. **On the first radio** the default SSID is NETGEAR.

Create an SSID for your group by using the first three letters of the first name of each person in your group. (For example, **bilmardou** for Bill, Mark, Doug). Use this nine-character string as the SSID. Type it in entirely in lower case. *NOTE: The SSID is case sensitive just like a password*.
For the second radio NETGEAR-5G is the default SSID. **DO NOT CHANGE ANYTHING OR CONNECT TO THE NETGEAR-5G RADIO!** We are going to totally ignore the NETGEAR 5-G portion of the router in order to keep things simple. Please make sure all of your changes are to the first radio which now should now have a 9-character name, as the SSID.
Please make sure to click the **Apply** button at the bottom to save your changes on this screen. The router has to reboot so it will take a few minutes before the 2 radio LED lights come back on. DO NOT DO STEP 20 UNTIL THE LIGHTS COME BACK ON!

3. What SSID did your group use? What does an SSID tell you?

Connect a computer or mobile device TO your wireless network

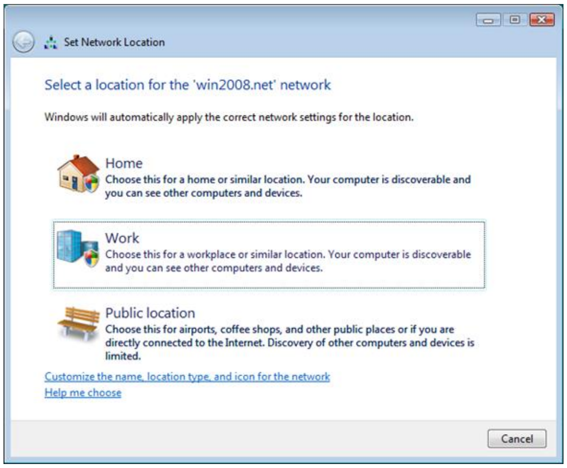
20. Follow these steps to connect computer #2 to the wireless network.
    a. Open the dialog box that shows what wireless networks are available from the Wireless icon in the Windows Notification Bar located near the clock in the lower right-corner of your desktop.
    b. Click on "Refresh network list" to ensure you are not looking at old information. You should see your group's SSID name on the list. Do not connect to anything with a –5G, as that represents the second radio.
    c. **Click your network's SSID name** and then click **connect** at the bottom of the list. You may get a warning window about the danger of connecting to an unsecure network. Click on **Connect Anyway**.

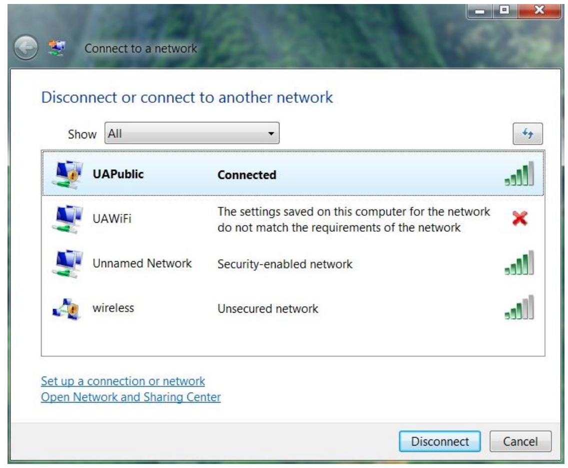


4. Where do the names of available wireless networks come from? How do you know from examining the list of names of available wireless networks whether or not a network is open or uses encryption?

5. When might it be preferable to connect to the Internet using a Wi-Fi connection rather than a cellular connection on your mobile device?

Note: In Windows 7, the first time you connect to a network, sometimes you are asked to classify its location type as home, work, or public. When you are connected to a public location, Windows 7, if told it is a public location, disables all network and sharing to protect your information. You can change what kind of connection it is at any time by modifying the settings for that connection.
Windows may not display the Set Network Location dialog box immediately. You may continue with the exercise regardless of whether or not you set the network's location.





21. Follow these steps to connect your mobile device to the wireless network.
    a. Look for wireless options on your device's settings screen to configure wireless access.
    b. Select the SSID of your wireless network to connect to it.
    c. If necessary, use a search engine to find more complete instructions on how to connect your particular mobile device to a wireless network.

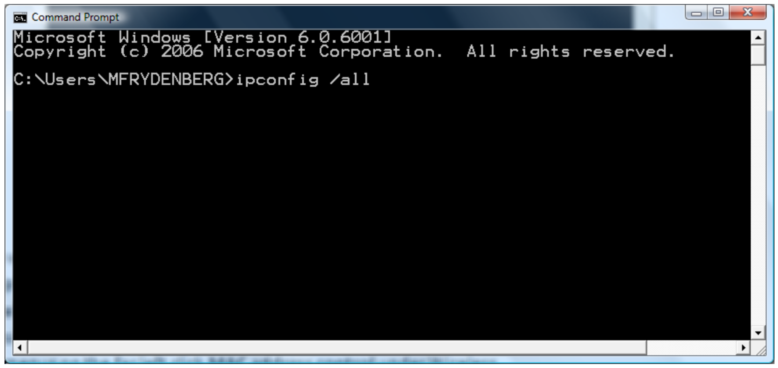
22. **Computer #2 and your mobile device should now be connected to your wireless network.** If the router has Internet access, the wireless computer and mobile devices also should have Internet access. Open a browser on the computer and mobile device connected wirelessly to your network and see if they can connect to a site on the Internet.

Find the IP and MAC addresses of your computer AND mobile device

Your computer or mobile device's IP address consists of 4 numbers separated by periods. It may also be called the IPv4 address. If your device has an IP address, which verifies that it is connected to a network. The MAC address (sometimes called the *physical address)* consists of 6 sets of two digits separated by dashes or colons. It is a number that uniquely identifies your device.

You will need the IP address of your computers or mobile device to verify your connectivity to the network using the Attached Devices list (see step 24). You will need the MAC address so you can allow specified devices to access your network. (See step 30).

23. Follow these steps to find the IP and MAC addresses for Computers #1 and 2, and your mobile device.
    a. To find this information in Windows:
        - click the **Start** button in the lower left corner and select "All Programs".
        - Select "Accessories" and then "Command Prompt".
        - In the command window,type **ipconfig /all** and press <ENTER>. (make sure there is a space between ipconfig and the /).



Issuing the ipconfig /all command generates several screens of information. **Each Bentley computer has 3 MAC or physical addresses associated with it, so make sure you are looking at the correct one for your machine's connection.**

When looking at the results of the ipconfig /all command, Computer #1's IP address (IPv4) and physical (MAC) address are located under *Ethernet adapter Local Area Connection*. Computer #2's IP address is located under *Wireless LAN Adapter Wireless Network Connection.*

b. To find your IP and MAC address on your mobile device:
  - On an iOS device, from the Settings app, tap Wifi, locate the network to which you're connected, and tap the arrow near the network name to reveal the IP address. Tap Settings, General, About to find your MAC address.
  - On an Android device, tap Settings, Device Settings, Status to view your IP and MAC addresses
  - Use a search engine to find more detailed instructions to find your IP or MAC address on your device if necessary.

Write down these values for each device and include them in your Lab Report

Device	IPv4 Address	MAC Address
Computer #1		
Computer #2		
Mobile		

6. Enter the information from the IPv4 and MAC address table above in your lab report.

Why should you look for Computer 1's IP address under the Ethernet Adapter Local Area Connection, and Computer 2's IP address under the Wireless LAN Network Connection section of the ipconfig results?

SEE WHICH DEVICES ARE CONNECTED TO YOUR NETWORK

24. The Attached Devices list (on the Netgear menu) identifies the computers connected to the router by their IP addresses (and specifies whether they are connected via a wired or wireless connection). On the wired computer, click the menu choice **Attached Devices** on the router's menu list to see a list of what computers are connected to it.

> *7. In "Attached Devices" which devices are associated with the IP addresses listed?*
>
> *8. Is anyone else connected to your network? (How do you know?)*

You can use the Attached Devices menu choice on the router at any time to check and see who is actually connected to your router. Remember this tool as you do the rest of the Lab.

Important note: You cannot see MAC addresses or IP addresses for other computers in the black box. Only your computer's information will show there. The router sees all of the computers and the Attached Devices menu option on the router will show you everyone attached to that router.

25. On computer 2 and your mobile device, choose Disconnect from a network to **disconnect them** from your wireless network.

> *9. Once you disconnect computer #2 and your mobile device from your wireless network, open a web browser and visit a web site such as google.com. Do you have Internet connectivity? If so, to which network are you connected? If not, why did you lose connectivity?*

For the next three sections, keep in mind that your router has 2 radios. Make the changes listed to only one of the radios so you can see the difference between what happens on the one you are changing. Experiment with both machines and switch connections to see just how your changes affect both machines. The first radio is the one you want to change and these changes only affect the network that has your SSID. When the Lab tells you to connect to the wireless network, **it is referring to the one with your SSID not the NETGEAR-5G network.**

STOP broadcasting your network's ssid

26. On the router in the Wireless settings, uncheck **Enable SSID Broadcast** on the Wireless Settings screen. Click Apply at the bottom of the screen. This does not shut off the network, it only hides the name. On computer#2 and your mobile device (which now are disconnected from your network), determine the wireless networks that are available. Your network SSID should not appear. You will find networks at the bottom of your available wireless network list that have hidden SSIDs. One of these is probably yours but without an SSID there is no way to tell.

To connect to your network using Computer #2

a. Left-click the wireless icon in the bottom right-corner of the task bar to see a list of available networks and indicate if you are connected to any of them. (If you are connected to airfalcon please click disconnect)
b. At the bottom; click on "Open Network and Sharing Center".
c. On the left side of the Network and Sharing Center screen click on "Manage Wireless Networks".
d. You should see your network on the list.

- **If your network is on the list**, right click it and click properties. You will get a list of three check-off boxes for Auto Connect, Preferred Network and "Connect even if the network is not broadcasting its name". You should check the first and last ones but not the middle one. Also note the Security tab which you will be coming back to when we do the security part of this exercise.

- **If not** click "add" at the top, click "Manually create a network profile" and add the information about your network. You are required to select a security choice and at this point you have none so select the "open" option. Note the check box for automatic start (if checked your computer will automatically connect if it sees this network) and the one for "Connect even if the network is not broadcasting" which needs to be checked if you want to see your network when the router is not broadcasting the SSID. Click next and then close.

Note: You may find that your computer has added a 2 next to the SSID on your computer. The SSID has not changed, the 2 is not part of the name. This is how Windows avoids confusion if an SSID has been added to the list when there is already one there with that SSID. You can always delete the old one.

To connect your mobile device to a network with a hidden SSID:

- On an iOS device, tap Settings / WiFi Networks / Other, and enter the network information.
- On an Android device, tap Settings, Wi-Fi, Add Wi-Fi network, and enter the network information.
- Use a search engine to find more detailed instructions to find your IP or MAC address on your device if necessary.

After you have completed **one** of the two options above you should get your network on the list of available networks and you should be able to connect. Verify that you are connected (how?). If you cannot connect your settings for that network do not match the settings for the network on the router. The settings must match for the computer or mobile device to connect.

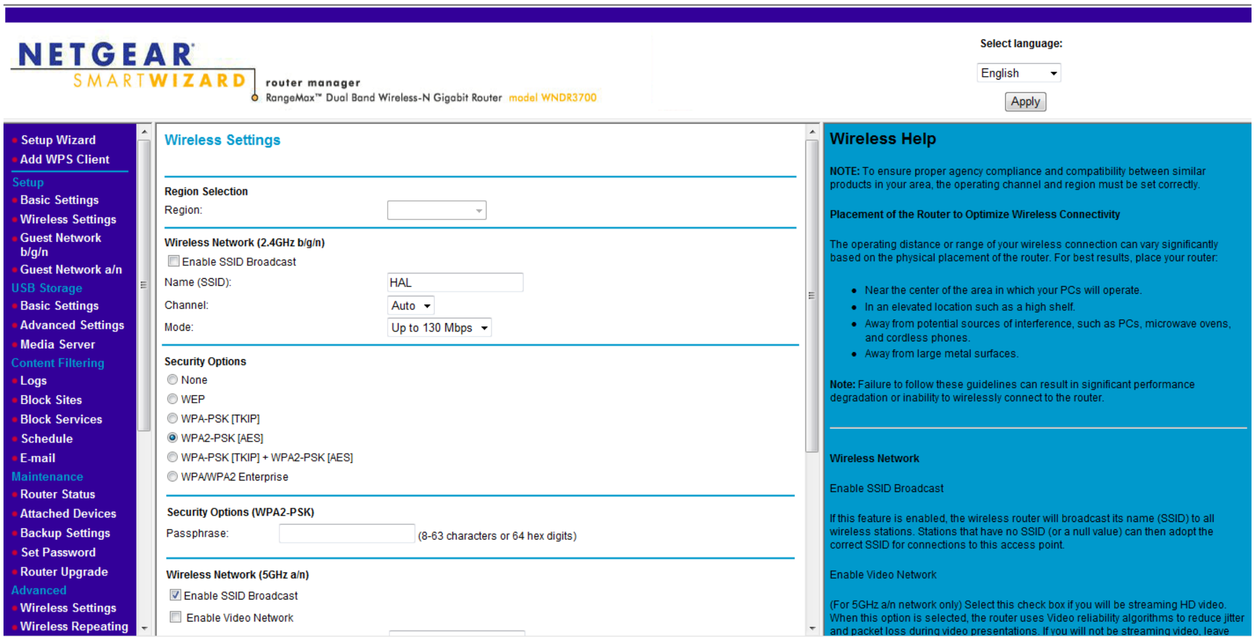
10. How do networks that don't broadcast their SSIDs appear in the "Connect to a Network" *dialog box?*

11. Consider a network that doesn't have encryption and also doesn't broadcast its SSID. Do those two things make your network more secure or less secure? (explain)

ADD encryption to your network

27. **On the router:** (Computer #1) click on the **Wireless Settings** choice on the far left side if you are not already there.

28. Change the security from "none" to "WPA2-PSK [AES]". The screen should look like this:



Add a key (Passphrase) to this screen. This is a very tricky task as explained on the router security page. You can type in a phrase as long as it is between 8 and 64 characters and the software will convert it to a hex string or you can type in a 64 character hex string. Many people use a word or phrase that they can easily remember. If you prefer using a hex string, use this one: **11bb22bb33bb44bb55bb66bb77** . As with all passwords this string is case sensitive. Please write down the password you use so you will have it for future reference.

29. Click **apply** at the bottom of this screen and wait, **this change will take a few minutes to go through.** Refresh your list of wireless networks on the wireless. **You will need to reconnect both devices.** When you do, it will prompt you for the key (passphrase) and you must type it in correctly. Remember, the key is case sensitive! **If you have trouble connecting use the same process you used earlier to modify each wireless device's settings for your network.** You will need to add the encryption settings on the Security tab of the Properties window for your SSID. Again, if the settings on your computer match the settings on the router you will connect. If the settings do not match there is no way you can connect.

Note: If neither computer can connect to the network, reconfigure the router using computer #1 to broadcast its SSID. See if that helps. Make sure that on computers 2 & 3, Security Type is set to **WPA2-Personal** and that Encryption Type is set to **AES.** The passphrase is case sensitive so make sure that is correct too!

12. What does adding WPA2 encryption do for your network?

13. Name three different steps you took to secure your network so far.

14. Can you add encryption without using a passphrase?

ALLOW network ACCESS Based on MAC ADDRESS

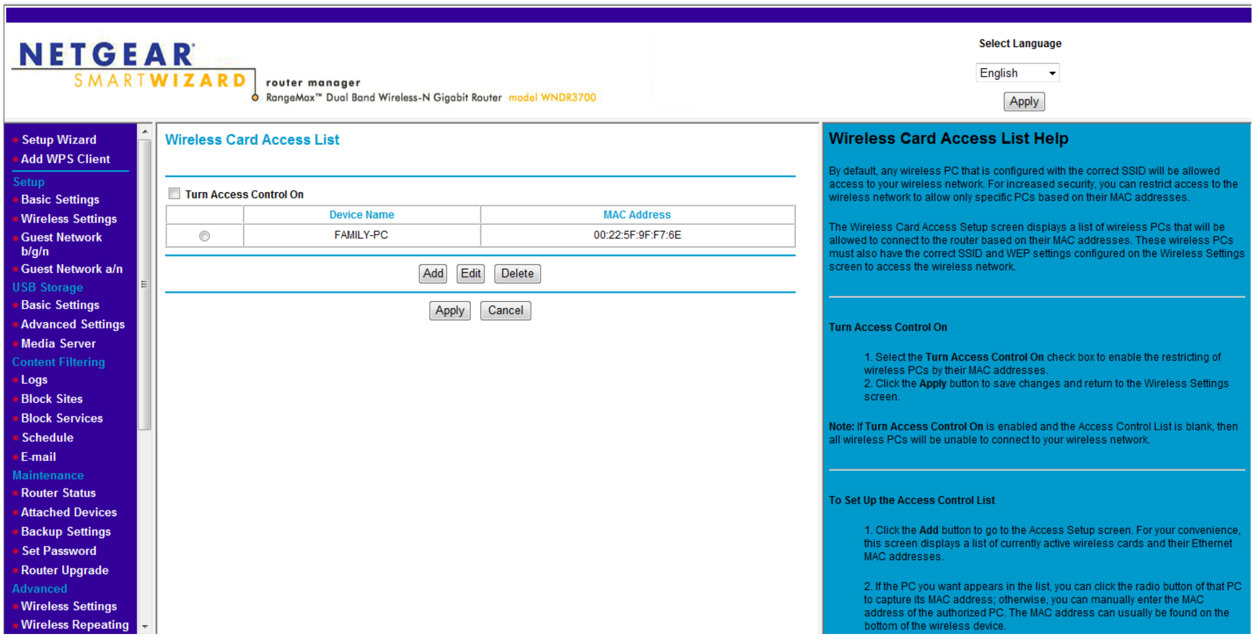
To make the network even more secure, specify the MAC (physical) addresses of only those computers that can connect to it. In this section you will let computer #3 access the network by entering its MAC address. Computer #2 will not be able to access the network.

30. Find the MAC address of your mobile device so you can let it access your network. (See step 23). **Make sure you have the wireless MAC address and not the Bluetooth or Local Area Network MAC addresses!**

31. Using Computer #1, follow these steps to configure the router to permit access based on MAC address:

    - Clickon the other **Wireless Settings** in the **Advanced** group.
    - Near the bottom of this screen find "Wireless Card Access List"
    - click on "Set Up Access List".
    - Check the box "Turn Access Control On" and click add.
    - If the wireless device appears in the **Available Wireless Cards** list, you can select the radio button of that device to capture its MAC address.
    - If your wireless device is not listed, make sure that it is configured correctly, and then click the **Refresh** button to update the list of available wireless devices.
    - If computer 2 is on the list but not the mobile device, then add computer 2. If the wireless device is still not listed you can add the MAC address and whatever description you would like. Use the instructions to the right on the Netgear screen for more detail. **You must check the box at the top to "Turn Access Control On". Often this requires 2 tries to get the check in the box to stay.**

    NOTE: This is a very poorly designed page on the router. There are actually 2 lists, one of the connected machines and one of the MAC address on the list to get access. It is very difficult to tell just which list you are looking at. It's not you that is the problem. Whoever designed this for Netgear hopefully is not working there anymore.



32. Verify that your mobile device can connect to your network, but computer #2 cannot (assuming both could connect before you enabled MAC address control).

15. Why would you want to add this level of security (MAC address filtering) to your network? (please explain)

Manage YOUR Wireless Networks

33. On computers 2 and 3, open the Network and Sharing Center (from the Control Panel or from Network Settings in the notification bar) and select Manage Wireless Networks. This page contains the names of every network you've ever connected to and saved settings on your computer. You may want to clean up this list if there are networks listed to which you don't connect frequently. If you right click on your network and choose Properties you can modify the connection settings for your network.

On your mobile device, view the Wi-Fi settings page to see names of networks to which you previously connected. Use a search engine to find instructions specific to your mobile device that describes how to remove names of no-longer-needed wireless networks from the list.

16. How can you configure computer #2 to remove or forget the name of the network you created in this exercise? (Write the steps to accomplish this on computer #2.) Take a screenshot showing the names that appear on the list of Wi-Fi networks stored on computer #2. Where did they come from?

17. How can you configure your mobile device to remove or forget the name of the network you created in this exercise? (Write the steps to accomplish this on your mobile device.) Take a screenshot showing the names that appear on the list of Wi-Fi networks stored on your mobile device. Where did they come from?

ACCESS NETWORKED STORAGE

34. Verify that computer 2 is connected to your network by adding its MAC addresses or turning off the Access Control.
35. To access network storage (this is really cool!) – connect a USB flash drive to the USB port on the back of the router. On each the two computers click on Sart and then right-click on "computer" (on the right side of the menu). Click on "Map network drive…". In the "Drive:" box choose the letter J:. In the "Folder:" box type: **\\readyshare\USB_Storage** and click Finish. A new file explorer window will open showing the files and folders on the flash drive. Everyone on your network can map and access the files on the USB flash drive. If you had a movie on the USB flash drive everyone on your network could watch it on their own machine. (make sure the USB Flash Drive is correctly plugged in to the router) Turn on your sound and play the video on the flash drive.

18. What could you use this "Network Storage" for on your network at home?

Running out of time? Save your Configuration (OPTIONAL)

36. OPTIONAL – **This step should only be done if you do not have enough time to finish.** You can save your router setting in a file on your wired computer. This would allow you to return the router to where you are now without going through the whole exercise again. To do this click on the "Backup Settings" on the router's left side menu and then click "Back Up". Make sure you know where you are saving the settings on your computer. When you connect the new router (any Netgear WNDR3700 router) click on the "Restore Saved Settings from a File" option under Utilities in the router's left side menu and follow the instructions to restore your settings. Everything you set **including the router password** will be restored to where they were when you saved them.

Clean up after yourself

37. When you have completed everything you want to or are required to do**, <u>you need to restore the router to its original state</u>.** This step will remove all of the changes you made to the router so don't do it unless you have completely finished the lab exercise. If you finish early – go back and start answering the questions. Make sure you have everything you need for the report BEFORE YOU RESET THE ROUTER!

Choose **Backup Settings** from the far left menu. Click on **Erase** then click YES. An "Updating Settings" window will display. It will require approximately 2 ½ minutes to clear the router and a login screen will pop up when it is finished. **DO NOT DO ANYTHING ON THE WIRED COMPUTER WHILE THIS IS TAKING PLACE.** THIS IS VERY IMPORTANT – THE NEXT GROUP WILL NOT BE ABLE TO USE THE ROUTER UNLESS YOU RESTORE THE DEFAULT SETTINGS CORRECTLY!

> *(Each group member should answer the last two questions individually with their name on their answer in the report.)*
>
> *19. What part of this lab exercise gave your group the most trouble and why?*
>
> *20. What did you learn from this exercise?*

Please make sure that your computer or mobile device can connect to airfalcon after you complete this lab exercise. If you have any trouble connecting do a full Windows shut down and then start the computer again. You should automatically connect to airfalcon but if not look at your available wireless networks list. You should be able to find airfalcon and the knowledge you obtained in this lab will allow you to open the properties of airfalcon and make any adjustments necessary.

Complete your lab report

Review your lab report. Make sure you answered all of the questions and included all of the screenshots and photos. Check with your instructor as to when your lab report is due. Submit the final lab report by sharing it with your instructor's GMAIL account (??????????????@gmail.com) on Google Drive as a collaborator.

Please make sure that all of the members of your group are listed by name at the beginning of the Lab Report since your instructor may not recognize you by your Google name!

IT101 Wireless Router Lab
Instructor's Guide

The IT101 Wireless Router Lab has proven to be very popular with students. It can be very frustrating for instructors unless some prep work is done ahead of time. This guide is designed to help you through the Lab and provide some of the answers to the questions the students will ask. Keep in mind that wireless networking can be very frustrating and that is one of the lessons of the Lab.

It is almost impossible to do this Lab effectively if you have not gone through the student instructions step by step yourself. Two of the routers are almost always available in the Smith 234 Lab and it is recommended that you go to the Lab and spend an hour doing the exercise before you present it to your students. You can connect the router to one of the Lab machines and use your laptop for both computer #2 and computer #3. Even better, find another IT101 instructor and do the Lab together!

One of the most annoying issues we see every time we do this Lab is computers that are infected with spyware or viruses. This Lab stresses the machine and if it's not clean the students will experience strange and unpredictable results. Before you do the Lab re-emphasize the need to run scans for both viruses and spyware. I suggest having them run malwarebytes available from http://www.malwarebytes.org/ This is a scan that takes a long time so don't run it in class.

WHAT YOU NEED TO KNOW BEFORE STARTING

This section of the Lab explains what the students need to know before they start. All but the last item are normally known or covered in class in the normal flow of IT101. Using Google Docs is not familiar to most students. You can skip the Google Docs/report part of the Lab but if you do they will not do everything in the Lab and some will just tune out. The Google Docs part of the exercise is designed to show them a collaborative tool that is actually used in business. The best thing you can do to make this work is to have them all setup Google accounts at least a week before they do the Lab. Some will already have accounts but probably have never used the documents or the calendar portions. For those who do not have Google accounts, suggest that they use the Gmail account as a "throw-away" email account when they fill in forms on-line. Have them build a document, past a screen shot into it and share it with you. You cannot paste anything except text directly into a Google Document so the screen shots need to be saved and the file is inserted into Google Docs. The instructions for this are now part of the Lab instructions. The other issue that has come up in the past is that students write the Lab up in Word and then just past the whole thing into Google Docs. This negates the whole concept of collaboration. Get them to all open the document during the Lab so that they can each add to it as they go along. When you are in the Google Document that they give you access to, you can pull down on the edit menu and click on "Revision History". This will list exactly who did what in the document. You can identify anyone who did not do much on the report through this tool. Telling them ahead of time will generally avoid the issue altogether.

HARDWARE

The only issue here is:

> They need to be in groups of three. Four works, two doesn't. The wired computer (#1) should be in the center of the group to encourage full participation by the entire group.

SOFTWARE

If you have anyone not using Windows 7, things will work but getting to the wireless setup is different. They should be able to handle it if they have done the rest of the course in something other than Windows 7. It would probably be good to use a non-Windows 7 machine as the wired (#1) computer if there is one in the group. Even an Apple could be used for the wired machine if necessary.

It really helps if you download and try out inSSIDer before they do the Lab. The package allows you to give them "the big picture" of what is happening in the room. I put inSSIDer up on the screen from my laptop so that everyone (including me) can see who's up and broadcasting.

GROUP MEMBERS AND ROLES

Emphasize that all changes to routers should be made on wired connections only. Making changes through wireless is very dangerous and should be avoided. The person sitting at computer #1 can switch with other people in the group so everyone gets to make changes on the router.

Lab Report

One issue here is how to do screen shots of the available networks. There are many ways to do it and this is a good example to use to show that sometimes one way doesn't work and other (sometimes older) way must be used. The Windows snipping tool is probably the way most will try to do it but this is a new Windows tool that most students are not aware of and in this case it doesn't work. Some of them are aware of the OneNote tool (Windows key + S) but this doesn't save in the correct format for pasting into Google Docs. Good old PrtScr is the other way and it is a good thing for them to be familiar with. The best format for saving is .gif and those will easily insert into Google Docs.

CONNECT THE ROUTER TO THE WIRED COMPUTER

At least 2 of your groups will connect the wires wrong. If they pay attention to the instructions, they will realize the problem before they boot the wired machine. Most groups don't. This means that they lose time figuring out what is wrong and then lose even more time shutting down and starting up the wired computer again. There is a short cut to this that will avoid the reboot but you need to practice it before you try it in class. You don't even need to be connected to a router to try this out but you do need to be connected to some network (wired or wireless). Click on the Start button and go to All Programs->Accessories and right click Command Prompt. Click on Run as Administrator. You will get the black "DOS" window that looks just the same as if you had clicked on run but because you are an administrator you can use the following commands that will not work otherwise. At the prompt ipconfig /all will list all of the ip addresses and MAC (physical) addresses just like the students will be doing in step 23. You don't need this now however. Instead, type ipconfig /release . This will release every IP address for all network connections. When the prompt comes back type ipconfig /renew . It will take a minute but the machine will attempt to renew the IP address on every network connection it has. In the case of the wired computer, it will get a new IP from the router without doing a reboot (assuming that the wires are now set up correctly). This can save 15 minutes for the group that got started wrong.

If the last group that used the router did not reset it to default the group using it now will not be able to get into the router because it has a password that only the last group knows. The simplest way to deal with this is to get the group another router. They should not have to reboot the wired machine as its IP address should be valid on the replacement router. If no other router is available, you will need to do a physical reset of the router. This is done by depressing the reset button on the bottom of the router for 7 seconds while the router is on. The button is recessed and will require a paperclip or something to depress. Keep holding it down until you see the lights go out. It may require more than one try to get it reset.

CONFIGURE THE ROUTER ON THE WIRED COMPUTER

The thing to emphasize here is that the router has a Web page built in so the wired machine is going to that page, not a site on the Internet. Every setting on the router that can be changed is changed through the browser using the built-in Web page. The toughest part is figuring out just where on the page a particular setting is. The Lab instructions point them to the correct menu choice if they read it.

Changing the password on the router is a primary security measure. Otherwise anyone can get into the settings page and change the settings. In the classroom with all of those routers fired up, one group could accidently change another group's settings leaving both groups totally confused. This is also a good time to mention that changes on the router do not take place instantly. Many of the changes require the router to reboot which takes time. Even the changes that do not require a reboot take a couple of minutes to take effect. Tell them to sit back and look ahead while they give the router a chance to meet their demands.

SET THE SSID FOR YOUR NETWORK ON THE WIRED COMPUTER

This change will identify which router is which since the default is to show up in inSSIDer as a Netgear router. Remember to refresh the inSSIDer display to see the SSIDs show up on your monitor if you are using inSSIDer to monitor the airwaves of your class.

Keep in mind here that each of these routers has 2 radios. To save confusion the students have been told to label the two networks their router is broadcasting differently so they can make changes to and monitor just one of the networks. The most common mistake is to label them identically which leads to total confusion. Emphasize the need to label properly and then ignore the 5G network as they proceed.

CONNECT TO THE ROUTER OVER YOUR WIRELESS NETWORK

Now we get the other 2 group members involved with their machines. Most will be connected to a campus network and may need to disconnect in order to connect to their own network. This is also where the problem computers (infected computers) start to give their owners trouble. Make sure everyone connects before they move on. It may be a good idea to take a minute to talk about the Set Network Location dialog box. This is really important for anyone connecting to an unknown wireless connection in a public place and is a great feature of Windows 7. Depending upon the state of their wireless connection, the Set Network Location dialog box may not show up.

Finding the IP address and the MAC (physical) address is a very important part of this Lab and one that is easy to test later. They need to understand that there is a MAC address for every network adaptor (three in the current HP machine, Bluetooth, wired and wireless) and an IP address for every current connection. The router tracks the machines that are connected to it by their IP address which is given to the computer by the router. The Attached Devices list shows everything connected to the router and becomes an important tool that the group can use at any time to figure out what is connected to their router and what is not connected.

STOP broadcasting your network's ssid

This is the simplest security that anyone can apply. It doesn't give much protection from folks who use tools like inSSIDer but it keeps the average person out because they don't even know the network is there. The most important part of this section is making the students familiar with the procedure for adding a network that doesn't show on the Windows list of wireless networks.

ADD ENCRYPTION TO YOUR NETWORK

There are multiple types of encryption available on today's routers. The basic WEP that has been a standard since the beginning of wireless routers can be broken in less than 10 minutes with tools readily available on the Internet. WPA was developed as a replacement but was also broken. WPA2 was next and has also been broken. Older wireless cards cannot do WPA or WPA2 so these choices may not be good ones for homes with older machines. Some of the versions of WPA require a Radius server which most people do not have. The Lab uses basic WPA2-PSK which works without a server and is more secure than WEP. Students should be cautioned that it is almost impossible to make a wireless network secure and that the TJ Max break-in was done from a car in the parking lot using standard wireless networking.
Regardless of which encryption is used, the type of encryption used on the router must match what is used on the wireless computers or they will not be able to connect even with the correct password. Encryption does not affect any of the wired ports which is another reason to only make changes to the router through a wired machine.
The password (referred to as a key in wireless lingo) is required to be a hex string by the encryption software. Most routers like our Netgear allow the user to type in a word or phrase and the router converts it to hex. This is a good opportunity to introduce them to a good key for wireless which is an easy to remember hex string 11bb22bb33bb44bb55bb66bb77 .
Remind students that one tool they have when dealing with connection problems is to turn the SSID broadcast back on. If they can't connect with the encryption turned on, they should enable the SSID broadcast and see if they can get connected. If so, they should turn off the SSID broadcast while connected and see if they can maintain the connection or reconnect.

ALLOW NETWORK ACCESS BASED ON MAC ADDRESS

Another security tool provided on most routers is MAC filtering. The user gives the router a list of valid MAC addresses and the router will only connect to machines with those addresses. This is a good exercise in that it gives them a reason to be able to find their various MAC addresses. Most will miss-type at least one of the group's MAC addresses and will have trouble connecting. Make sure the addresses they type in match the actual MAC addresses of the wireless machines again remembering that only one of the three MAC addresses each machine has will allow it access (the wireless MAC address). Like the encryption, the MAC filtering doesn't apply to wired machines so Computer #1 will still connect no matter how badly they mess up the MAC addresses. Again, make sure students are aware that MAC addresses can easily be spoofed and a simple tool that picks up wireless traffic can identify the valid MAC address and allow a rouge machine to spoof the address and still get into the network.
The screen where the MAC based access is set up is somewhat confusing. Netgear did not do a good job with this screen and most students are likely to have trouble differentiating between the list of MAC addresses available and the list of MAC addresses allowed a connection.

MANAGE YOUR WIRELESS NETWORKS IN WINDOWS 7

We added this section to make students aware of the great tool Windows 7 has for managing the multitude of wireless networks that students encounter. Most students are not aware that Windows keeps a record of the wireless networks the machine has connected to in the past. They may want to do some cleanup here to cover their tracks.

NETWORK STORAGE

The Netgear router has the ability to use a USB memory stick as a network storage device. Memory sticks are supplied with the routers so everyone can try this out. Make sure that the MAC filtering has been turned off or all machines have been added to the list. The computers must be connected to the group's network in order for the storage to work. There is a video on the memory sticks that is easy to identify when a group gets the memory working.

CLEAN UP AFTER YOURSELF

This is a very, very important step. If the router is not returned to the default settings, the next group will not be able to get into the router. Please make sure every router gets reset before they disconnect the wired machine. Depending upon time, you may have some groups that are not able to finish the Lab. They can back-up the router settings to the wired computer BEFORE resetting the router. The backup will allow them to use any NetgearN600 router and restore their settings (including the router password) to the router. I keep 1 of the routers in a paper box in the Smith 234 Lab so that the students can go in and pick up where they left off with the router.

The router can be reset to default using the reset button on the router. This is much harder than the software reset. You must hold in the reset button for 7 seconds while the router is on in order to get a reset.

Complete your lab report

Please make sure you replace the generic Gmail address with yours before you distribute the Lab to your students. The reason you need to be a collaborator rather than a viewer is that you do not get the "Revision History" tool as a viewer.

Incorporating a Human-Computer Interaction Course into Software Development Curriculums

Thomas N. Janicki
janickit@uncw.edu

Jeffrey Cummings
cummings@uncw.edu

R. Joseph Healy
healyj@uncw.edu

Information Systems Operations Management Department
University of North Carolina Wilmington
Wilmington NC 28403

Abstract

Individuals have increasing options on retrieving information related to hardware and software. Specific hardware devices include desktops, tablets and smart devices. Also, the number of software applications has significantly increased the user's capability to access data. Software applications include the traditional web site, smart device applications and web pages that emulate apps on mobile devices. The importance of high user satisfaction is critical as users will switch quickly to other devices or sources for their information needs. To assist in developing high impact and positive user satisfaction are the theories from the field of study known as Human Computer Interaction (HCI). This research summarizes several of the key theories from HCI and recommends the placement of learning modules related to HCI in current software development courses as well as proposing an updated standalone HCI course into MIS and CIS curriculums.

Keywords: HCI (Human Computer Interaction), MIS Model Curriculum, IT Model Curriculum, Software Development

1. INTRODUCTION

The importance of sound design principles into software development courses has become more important with the expansion of development for multiple devices. Recent research reports smartphone and tablet ownership continues to grow with 58% of Americans owning a smartphone and 48% owning tablets (PewResearch, 2014). The increased use of mobile technologies has even caused a shift in device and Internet usage. In 2014, for the first time ever, mobile devices accounted for more Internet usage (at 55%) in the US compared to PCs accessing the Internet at 45% (O'Toole, 2014). Given the small available 'real estate' of smart devices and tablets, HCI curriculum needs to be expanded to cover these devices especially with the increased pressures on designers and developers to build their output with a concern for user ease of use. Implementation of "Mobile first" development via tools such as Bootstrap has also increased the need for enhanced HCI concepts in software development curriculums.

The current 2010 IS Model Curriculum (Topi, et.al, 2010) has an elective in the curriculum related to HCI: "Introduction to Human-Computer Interaction (HCI)". The 2008 IT Model Curriculum (Lunt et. al, 2008) places more emphases on HCI principles and proposes up to six courses in an HCI track.

The goal of HCI is to make computers/software more usable and adaptive to user needs, ultimately developing interfaces that minimize the barrier between human mental models and the system/software's ability to accomplish the desired task (McCracken & Wolfe, 2004). Developers are taught how to code, but are lacking knowledge in what makes a user desire to use one program over another. By offering an introductory course in HCI, students can learn to think of designing software tools from a more user-centered viewpoint. This becomes critical as developers now have to deal with real-estate and increased emphasis on user experience.

This research has two goals. The first goal to provide examples of specific HCI concepts that may be incorporated into existing software development courses. The second goal of this research is to expand the recommended course syllabus for the model HCI course with increased topics and readings and design concepts with a mobile emphasis.

The outline of the paper will be a discussion of HCI principles, summarizing current best practices, an analysis of currently offered HCI courses and an expanded syllabus and reading list for a HCI course in a model MIS or CIS (Computer Information Systems) curriculum. It assumes the sponsoring school only has room for one HCI course in its elective list. If a host university does not have the capability for a full course offering, then modules from the expanded syllabus may be incorporated into current software development courses.

2. HCI PRINCIPLES

30 years ago the researchers in the HCI field were considered rebellious because they broke the disciplinary boundaries of computing at the time. The goal of these researchers was to present information in comprehensible formats by creating better menus, developing GUI's (graphical user interface) based on direct manipulation, improving input devices, and designing effective control panels (Schneiderman, 2012).

A major advance in HCI was the creation of the GUI in the 1980's. Following the GUI was the development of the desktop and desktop icons. The problem with desktop icons is that they can quickly become cluttered, making finding files and folders cumbersome, the opposite of the original purpose of icons. Next email created networks where people communicated through computers with other people. This was the beginning of social computing, which has evolved into today's tools such as instant messaging, wikis, and social networking (Carroll, 2013).

HCI is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them (ACM - SIGCHI). The goal of HCI is to improve the user's ability to complete a desired task by making the computer more usable and receptive to the user's needs (Jose et al., 2014). Users of advanced hardware machines are often disappointed by the cumbersome data entry procedures, obscure error messages, and intolerant error handling confusing sequences of cluttered screens have become the norm rather than the exceptions, as many researchers in the field have noticed. In particular, novice users feel frustrated, insecure, and even frightened when they have to deal with a system whose behavior is incomprehensible, mysterious, and intimidating (Bertino et. al, 2008). To understand what users are looking for, one must have a clear definition of usability which is: "the user can do what he or she wants to do the way he or she expects to be able to do it, without hindrance, hesitation, or questions" (Welsch, 2012).

The major contributors to the science of HCI include psychology, ergonomics and human factors and computer science as shown in Figure 1. An additional six areas also contribute to effective HCI designs. These are also detailed in Figure 1.

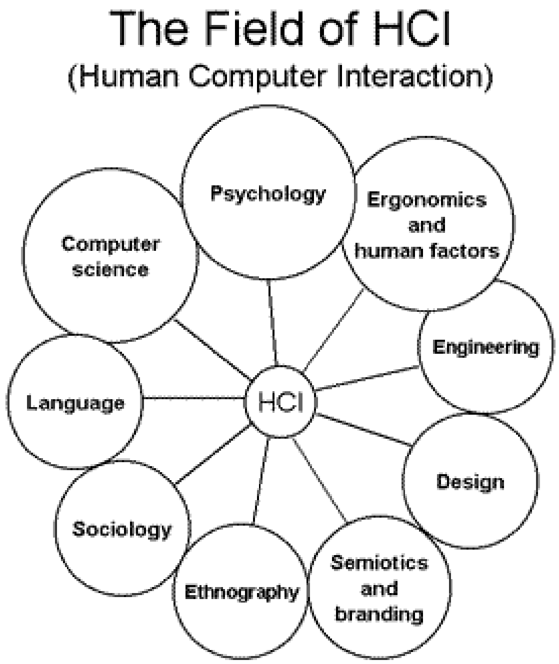


Figure 1 . Fields integrated in HCI (ACM SIGCHI).

As a result of technological advances in displays, sound, graphics, conceptual models and the physical design of input devices have contributed to improve the HCI experience. As the technological advances have increased the user experience, the application of psychological principles has become an area to include in course design as these principles are important to the design of software tools and web site interfaces, along with the effects of said principles on the implementation and usability of information systems.

Intersection of HCI and Psychology
The subject of human informational processing has provided a dominant theoretical framework for the consideration of human factors issues in HCI. Two of the key principles in the intersection between psychology and HCI is the consideration of cognitive science and perceptual-motor interaction (PMI) and performance. (Carroll, 1997)

Cognitive Science
Cognitive science is the scientific study of the mind and its processes, and is essential to understanding how users perceive an interface. Included in the cognitive science theories is attention (Cherry, 1953). Attention is the process through which information enters into working memory and achieves the level of consciousness. The important characteristics of attention are:

- It is selective, and allows only a specific subset of information to enter the limited processing system.
- Focus of attention can be shifted from one source of information to another.
- Can be divided, within certain limitations, to selectively attend to more than one information source at a time. (Cherry, 1953)

Vision is the primary modality of information transfer in HCI, however research is showing that visual-auditory interaction is becoming increasing relevant (i.e. think hearing and seeing a notification alert for an email or text message while reading information from a web page) (Ying et. al, 2011).

Furthermore, it was also reported that typing on a keyboard may in fact hinder recollection. The correlation of these findings to HCI is in an area called haptics or tactile feedback technology which takes advantage of the sense of touch. Examples of haptics are using vibration in the controls of video games and phones as well as enhancing the feeling of remote control of machines and devices by incorporation tactile sensors that measure force exerted by users on the interface (Robles-De-La-Torre, 2013). Another application of this technology involving the sensorimotor complex is using a stylus to interface with devices.

Another way interfaces might adapt is to manage interruptions based on the user's cognitive state. Cutrell, Czerwinski & Horvitz (2001) have shown that interruptions disrupt thought processes and can lead to frustration and significantly degraded task performance For example, if a user is thinking really hard, the system might be able to detect this and manage pending interruptions such as email alerts and phone calls (Tan, Nijholt, 2010).

Perceptual-Motor Interaction
Perceptual-Motor Interaction and Performance (PMI) is the foundation behind the evolution from the mouse, keyboard, and joystick to todays embedded, gestural, and tangible interfaces where people use their body to directly manipulate information objects. Many new laptops and most mobile devices support multi-touch, allowing the fingers and gestures to control the device, while some video game systems such as the Wii and Xbox use body

movements to interact with objects. These developments were born by researchers investigating the use of information-processing approaches to understand the translation of perceptual into motor space and the interaction of attention and action planning (Welsch, 2012).

An example of research in this area includes early studies performed in the 1960's and 1970's measured the error rate and speed of subjects completing a cursor positioning task using four different devices (mouse, joystick, step keys, and text keys). The speed measurement consisted of "homing time" (time taken to engage the control device and initiate cursor movement) and "positioning time" (time to complete the cursor movement). While the mouse was shown to have the poorest homing time, its advantage in positioning time produced the fastest overall time (Card, 1983).

Recent Advances in HCI Research

More recently, research has started to take into account more detailed interaction with the technology and presentation on that technology. Areas of interest have included eye motion research and haptics. Eye movement research has focused on what draws the eyes to various regions of a web page (on any device). With the increased focus on mobile devices incorporating touch, haptics research has gained popularity as we try to understand tactile aspects of HCI. In the following sections, we briefly discuss each of the areas of research.

Eye motion research

Eye movement patterns is an emerging research area which centers on studying the pathways a user's take when viewing a page. Websites exist to communicate information to users. Studying how the information is visually processed by the human eye therefore is an aspect of design that must receive attention. An example involves the Credo Mobile website.

The goals of the page were to: show a phone the customer may be interested in purchasing, display the company name, and guide the visitor to the purchase button. As shown in figures 2 to 5 in Appendix A, most of the hotspots were located in areas of the screen that were pertinent to the three goals for the page., Considering the data, the company redesigned the site according to the suggestions of the eye-movement study, locating the phone, company name, and buy button in the proven hotspots (oneextrapixel.com. 2013).

A more traditional research study on the identification of hotspots and the possibility of predicting areas of high attention was conducted at Microsoft (Buscher, Cutrell, Morris, 2009). Their report details how people allocate their visual attention when viewing web pages. They detail how an understanding of visual attentiveness could open the door to a variety of innovations, ranging from improved Web page design to the creation of compact, yet recognizable, visual representations of long pages. The goal of the study was to use visual attentiveness in a predictive manner." The study involved 20 users who viewed 361 different pages.

Key findings from their research include:

- The entire right third of the page is neglected for both information foraging and page recognition tasks.
- The center-left, top-left, and center-center regions are the most important for information foraging tasks.
- For recognition tasks, the top-left dominates
- Models of linear regression and decision trees can be used to render the most important HTML elements for optimal page recognition
- Prediction methods work well and find the most important elements for recognizing a page; however, they are biased to the upper left-hand side of the page
- Depending on screen size (desktop, laptop, mobile), methods can be used to emphasize more of the most important elements as identified by their calculated predictions (Buscher, Cutrell, Morris, 2009).

Figure 6 in Appendix A illustrates the results of their study. More recent studies have expanded this research by focusing on banner ad placement to understand user focus (Resnick & Albert, 2014). Understanding how websites communicate information is increasingly important as "real estate" becomes significant.

Haptics

Haptics involves the study of incorporating more senses into user experience, specifically the sense of touch (Nam et al., 2014). This technique is generally used for real time feedback. "Haptic feedback can be broadly divided into two modalities: vibrotactile and kinesthetic. Vibrotactile feedback stimulates human tissues. It's been employed in mobile phones, video console gamepads, and certain touch panels. Kinesthetic feedback focuses on the gross movement of the body. It has been employed in medical simulation trainers, programmable haptic knobs, video game steering wheels, and virtual reality systems" (immersion.com 2010).

Research conducted by Immersion Corporation on both tactile feedback touch panels and on vibrotactile mobile phones indicates that, when users are given a choice between HCI with visual feedback and one with visual and tactile feedback, they express a strong preference for the latter (Serafin, Heers, Tschirhart, Ullrich Ramstein, 2007). Their research concluded that reasons users prefer tactile feedback is that the feedback can make them more efficient and reduce their error rate and stress levels.

3. GENERAL DESIGN PRINCIPLES

Within the field of HCI, there are general design principles that are considered standard, meaning they are applicable to the design of any interface. General design principles from Stasko (2007), Stephanidis et. al (web resource) and Jacko (2012) include:

- Usability: ease of use and learnability of a software application, system, or website.
- Learnability principles: ease with which new users can begin effective interaction
- Predictability: I think that this action will do a certain function (i.e. clicking on a submit button will submit information entered in a form)
- Familiarity: does UI task leverage existing real-world domain knowledge?
- Generalizability: can knowledge of one system/UI be extended to similar ones? (i.e. cut and paste in different apps)
- Consistency: likeness in behavior between similar tasks/operations (interacting, output, screen layout)
- Accessibility: accessibility of a computer system to all people, regardless of disability and severe.
- Computer user satisfaction: the attitude of the user to a system – a key measure of system success. Involves psychological principles such as user perception of software's ability to accomplish desired tasks.
- Human interface design: designing interactive digital products, environments, systems, and services – more of a behavioral study.

The following are the human interface guidelines incorporated in the design of Apple's latest mobile operating system, iOS 7 (developer.apple.com):

- Deference: UI helps users understand and interact with the content, but never competes with it.
- Clarity: text is legible, icons are precise and lucid, adornments are subtle and appropriate, sharpened focus on functionality
- Depth: visual layers and realistic motion impact vitality and heighten users' delight and understanding.

Likewise, Shneiderman and Plaisant (2010) recommend eight rules of good HCI design in a little more detail for developers:

- Strive for consistency. Consistent sequences of actions should be required in similar situations; identical terminology should be used in prompts, menus, and help screens; and consistent color, layout, capitalization, fonts, and so on should be employed throughout.
- Cater to universal usability. Recognize the needs of diverse users and design for plasticity, facilitating transformation of content. Novice to expert differences, age ranges, disabilities, and technological diversity each enrich the spectrum of requirements that guides design. Adding features for novices, such as explanations, and features for experts, such as shortcuts and faster pacing, can enrich the interface design and improve perceived system quality.
- Offer informative feedback. For every user action, there should be system feedback. For frequent and minor actions, the response can be modest, whereas for infrequent and major actions, the response should be more substantial. Visual presentation of the objects of interest provides a convenient environment for showing changes explicitly.
- Design dialogs to yield closure. Sequences of actions should be organized into groups with a beginning, middle, and end. Informative feedback at the completion of a group of actions gives operators the satisfaction of accomplishment, a sense of relief, a signal to drop contingency plans from their minds, and an indicator to prepare for the next group of actions. For example, e-commerce web sites move users from selecting products to the checkout, ending with a

clear confirmation page that completes the transaction.

- Prevent errors. As much as possible, design the system such that users cannot make serious errors; for example, gray out menu items that are not appropriate and do not allow alphabetic characters in numeric entry fields. If a user makes an error, the interface should detect the error and offer simple, constructive, and specific instructions for recovery. For example, users should not have to retype an entire name-address form if they enter an invalid zip code, but rather should be guided to repair only the faulty part. Erroneous actions should leave the system state unchanged, or the interface should give instructions about restoring the state.
- Permit easy reversal of actions. As much as possible, design the system such that users cannot make serious errors; for example, gray out menu items that are not appropriate and do not allow alphabetic characters in numeric entry fields. If a user makes an error, the interface should detect the error and offer simple, constructive, and specific instructions for recovery. For example, users should not have to retype an entire name-address form if they enter an invalid zip code, but rather should be guided to repair only the faulty part. Erroneous actions should leave the system state unchanged, or the interface should give instructions about restoring the state.
- Support internal locus of control. Experienced users strongly desire the sense that they are in charge of the interface and that the interface responds to their actions. They don’t want surprises or changes in familiar behavior, and they are annoyed by tedious data-entry sequences, difficulty in obtaining necessary information, and inability to produce their desired result.
- Reduce short-term memory load. Humans’ limited capacity for information processing in short-term memory (the rule of thumb is that we can remember "seven plus or minus two chunks" of information) requires that designers avoid interfaces in which users must remember information from one screen and then use that information on another screen. It means that cell phones should not require re-entry of phone numbers, web-site locations should remain visible, multiple-page displays should be consolidated, and sufficient training time should be allotted for complex sequences of actions.

4. ANALYSIS OF CURRENT HCI OFFERINGS

This section will detail an analysis of the ACM (from the 2010 IS Model) model curriculum for an elective course in HCI as well as HCI courses offered at six universities. It will highlight the similarities and differences in order to provide a framework for an updated, current HCI course.

Per the 2010 IS Model Curriculum (Topi, et. al, 2012) the learning objectives for the HCI elective course are:

- Design, implement and evaluate effective computer interfaces.
- Understand the concepts of user differences and user experiences
- Understand the basic cognitive psychology issues involved in HCI
- Understand the different devices for input and output
- Interact with the software design process in order to create computer interfaces
- Understand the role of theory and framework
- Apply a number of design concepts
- Apply contemporary techniques to evaluate computer interfaces.

These basic learning objectives still are sound and form the basis of an updated syllabus for an HCI elective course for MIS and CIS students.

To gauge current course offerings and their content, research was done to find publically available syllabi for HCI courses. Five schools were chosen as they had detailed topics included in the syllabi. The schools investigated and their particular course numbers were: Bowling Green State University (BGSU) (CS 324), Carnegie-Mellon University (CMU) (HCI105), Loyola University (COMP388), Northeastern University (IS4300), Northwestern University (EECS330). As noted, the courses were ‘housed’ in various disciplines from Information Systems to Computer Science to Electrical Engineering/Computer Science to one with its own HCI major.

Table 1 details the common topics found in the curriculums for the introductory courses. The table also list the topics as found in the model ACM curriculum for HCI.

Topic	Reviewed Curriculum
Introduction to HCI and or History of HCI	ACM, all schools
Psychology – attention/cognitive	BGSU, Loyola, Northeastern, Northwestern
Task Analysis	ACM, BGSU, CMU, Northeastern
Interface evaluation	ACM, BGSU, CMU, Northeastern,
Web design	CMU, Loyola, Northeastern, Northwestern,
Feedback/Prototyping	ACM, BGSU, CMU Northeastern, Northwestern,
Heuristics/Usability/Usability engineering	BGSU, CMU, Loyola, Northeastern
Interface Design, User-centered design	ACM, BGSU, CMU, Northeastern, Northwestern

Table 1. Common Topics in HCI Course Curriculums

Understandably, the majority of the courses include many of the topics suggested by ACM. These topics correspond to the major principles of HCI.

Table 2 details topics that were only offered in one or two of the schools surveyed. It is interesting to note that only 2 schools out of the five have been able to provide specific instruction for mobile devices.

Topic	Reviewed Curriculum
SDLC	ACM, BGSU
Dimensions of interface variability – language, menus/windows, user support/doc/training	ACM
Wireframes	CMU, Northeastern,
Designing for mobile	ACM, CMU, Northeastern,
Programming languages – HTML,JS	BGSU, Northwestern

Table 2. Topics That Differ in HCI Course Curriculums

5. POTENTIAL SYLLABUS AND JUSTIFICATION FOR THE NEW TOPICS

Table 3 follows which is an abbreviated syllabus for a sample HCI introductory course. Table 4 in the Appendix B provides justification for the new topics as well as additional reading for instructors and students. The course can be summarized with the following topics:

1. Overview
2. The Past and the Future
3. Principles for Design
4. Understanding users and their tasks
5. Designing with the user
6. Basic human factors
7. Designing visual interfaces
8. Interface technology
9. Implementing GUIs
10. Evaluation and experimental design

Items in *italics* are new learning modules added to the model curriculum, while items in **bold** pertain to additional instructions for mobile devices.

Week	Topic	Topic details
Week 1	Introduction	• Why study HCI • History of HCI • Importance of interface design – examples that illustrate
Week 2	HCI : an overview	• Identifying daily personal interactions with technology • Major principles of HCI
Week 3	Psychology of HCI I	• *How does psychology apply to HCI* • *Human factors* • **User satisfaction**
Week 4	Psychology of HCI II	• *Cognitive Science - Human information processing* • ***Eye tracking*** • *Perceptual-motor interaction* • *Attention*

	Task Analysis I	• What is task analysis? • How is task analysis applied? • Use cases • User profile, needs analysis
Week 5	Task Analysis II	• Using task analysis as basis for design • In class exercise
Week 6	Interface Design I	• General design guidelines • Interface design rules • **Interaction styles (menus, touch, windows) – interface variability**
Week 7	Interface Design II	• *Applying psychology to interface design* • User goals/perception • Designing for a task
Week 8	HCI and SDLC/usability engineering model	• How does HCI fit into the SDLC
Week 9	Heuristics/ usability testing	• Importance of testing • Evaluating without users
Week 10	Incorporating user feedback/ iterative design	• Involving users in testing/designing testing methods
Week 11	Web design I	• How does HCI apply to web design • Wireframes
Week 12	Web design II/ evaluating HCI in webpages	• *Appearance/content and graphics* • *Methods for evaluating HCI in webpage*
Week 13	***Using JavaScript/ jQuery/ designing for mobile***	• ***Screen sizes and HCI considerations*** • ***Haptics***
Week 14	*HCI future/current research*	• *Incorporating advances in hardware/technology* • Future of interfaces/virtual reality/brain-computer interface

Table 3. Topics That Differ in HCI Course Curriculums

Additional justification for expanding the current concepts found in the model curriculum includes:

- Weeks 3 and 4: Psychology of HCI I and HCI II – the application of psychological principles to HCI is emphasized more heavily in this curriculum than others in order to provide students with a greater understanding of how psychological principles are applied to designing more effective user interfaces. Research of other course curriculums demonstrates that human factors (aka user psychology) are a major focus of contemporary HCI design. Covering user psychology in more detail will allow students to better understand how psychology is incorporated in the design process.

- Week 7: Interface design II – the emphasis here is on how applying the psychological principles.

- Week 12: Web design II – an additional lecture for implementing HCI principles covered in Web Design I lecture is needed. Using heuristic evaluations done by other students to provide feedback on interface designs.

- Week 13: JavaScript, jQuery, mobile design – HCI considerations for mobile device design and responsive webpages. Web applications and websites must be responsive to different devices and screen sizes without sacrificing usability. An introduction to jQuery and JavaScript will be covered in order to familiarize students with these popular UI tools.

- Week 14: HCI future, current research – emphasize importance of learning to use new technologies (hardware, psychological studies, ergonomic advancements). Promote continuing education by keeping up with new practices and tools by reading UI blogs. Good examples of blog sites:
    - http://hci-design.blogspot.com/
    - http://uxmag.com/

Resources including suggested books and websites can be found based on the various HCI topics on the potential syllabus in Appendix B.

As mentioned earlier one of the goals was to offer suggestions on potentially incorporating HCI concepts into current software development courses. This past academic year, a "Device Development Course" which is primarily a HTML5, CSS and jQuery course included new HCI modules. The modules included were:

- Week 1 – Introduction
- Week 4 – Task Analysis
- Weeks 5 and 6 – Interface Design
- Week 13 – Screen Size considerations.

Feedback from students in the course was generally favorable as the class moved from strictly 'coding' issues to why and where items should be placed on a device.

6. SUMMARY

As technology instructors we all face changes in order to stay current in our field. The model curriculums proposed by various groups help to found a foundation for many MIS and CIS course. This research project was undertaken to increase and summarize concepts in HCI that instructors of software development courses as well as specific HCI courses may use as background materials.

The research project also did an analysis of five current HCI offerings and merged the common threads between those courses with the ACM suggested curriculum. Finally the research project expanded the proposed topics with additional topics and potential background materials to enable MIS and CIS instructors to consider offering all or parts of the curriculum in current software development courses or stand-alone courses.

7. REFERENCES

ACM – SIGCHI Course curriculum. Retrieved 5/1/2014 from http://old.sigchi.org/cdg/cdg3.html

Bertino, E., Calo, S.,Chen, H., Li, N., Li, T., Lobo, J., Molloy, I., Wang, Q. (2008). Usability considerations in access control systems. Symposium on usable privacy and security.

Buscher, G., Cutrell, E., & Morris, M. R. (2009). What do you see when you are surfing? - using eye-tracking to predict salient regions of web pages. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Retrieved 9/9/2013 from http://research.microsoft.com/en-us/um/people/cutrell/chi09-buschercutrellmorris-eyetrackingforwebsalience.pdf

Card, S.K., Janko, J. (1983), The human computer interaction handbook: fundamentals, evolving technologies, and emerging applications (3rd ed.)

Carroll, J., (1997). Human–computer interaction: psychology as a science of design, International Journal of Human-Computer Studies Volume 46, Issue 4, April 1997, Pages 501–522

Carroll, J. (2013). Human Computer Interaction - brief intro. In: Soegaard, Mads and Dam, Rikke Friis (eds.), The Encyclopedia of Human-Computer Interaction, 2nd Ed.. Aarhus, Denmark: The Interaction Design Foundation. Retrieved from http://www.interaction-design.org/encyclopedia/human_computer_interaction_hci.html, 5/6/2014.

Cherry, E.C. (1953). Some experiments of the recognition of speech, with one and two ears. The journal of acoustical society of America, 25(5).

Cutrell, E., Czerwinski, M. & Horvitz, E. (2001). Notification, Disruption and Memory: Effects of Messaging Interruptions on Memory and Performance. In Hirose, Michitaka (Ed.), Human-Computer Interaction INTERACT '01, (Tokyo, July 9-13), IOS Press (for IFIP), 263-269.

developer.apple.com, Designing for iOS 7. (n.d.). Retrieved 5/1/2014 from https://developer.apple.com/library/ios/documentation/UserExperience/Conceptual/MobileHIG/

Jacko, J. (2012). The Human-Computer Interaction Handbook, J. Jacko Ed. CRC Press, Baca Raton Fl.

Jose, P., Miglani, S. & Yadav, S. (2014). Human Computer Interaction: Analysis and Journey through the Eras. *International Journal of Computer Science and Mobile Computing*, 3(4), 653-659.

immersion.com (2010), Value of haptics. (2010). Retrieved 9/13/2013 from http://www.immersion.com/docs/Value-of-Haptics_Jun10-v2.pdf

Lunt, B., Ekstron, J. Gorka, S., Hislop, G., Kamali, R., Lawson, E., LeBlanc, R., Miller, J., Reichgelt, H. (2008). Retrieved 6/1/2014 from http://test.sigite.hosting.acm.org/wp-content/uploads/2012/11/IT2008Curriculum.pdf

McCracken, D., Wolfe, R. (2004), User Center Website Development. Peason Education, Upper Saddle River, NJ.

Nam, C. S., Richard, P., Yamaguchi, T., & Bahn, S. (2014). Editorial: Does Touch Matter?: The Effects of Haptic Visualization on Human Performance, Behavior and Perception. *International Journal of Human-Computer Interaction*, (just-accepted).

O'Toole, J. (2014) Mobile Apps Overtake PC Internet Usage in U.S. Retrieved 5/31/2014 from http://money.cnn.com/2014/02/28/technology/mobile/mobile-apps-internet/

oneextrapixel.com, Eye movement patterns in web design. (n.d.). Retrieved from http://www.onextrapixel.com/2010/11/05/eye-movement-patterns-in-web-design/, Retrieved 9/9/2013.

Pew Research. (2014) Internet Project: Mobile Technology Fact Sheet. Retrieved 5/31/2014 from http://www.pewinternet.org/fact-sheets/mobile-technology-fact-sheet/

Resnick, M., & Albert, W. (2014). The Impact of Advertising Location and User Task on the Emergence of Banner Ad Blindness: An Eye-Tracking Study. *International Journal of Human-Computer Interaction*, 30(3), 206-219.

Schneiderman, B. (2012). The Human-Computer Interaction Handbook, J. Jacko Ed. CRC Press, Baca Raton Fl.

Serafin, C. Heers, R., Tschirhart, M., Ullrich, M.,Ramstein, C. (2007). User experience in the U.S. and Germany of in-vehicle touch screens with integrated haptic and auditory feedback. Proceedings of SAE world congress.

Shneiderman, B., Plaisant, C. (2010). Designing the User Interface: Strategies for Effective Human-Computer Interaction (5th Edition). Addison-Wesley Publ. Co., Reading, MA.

Stasko, J. (2007). Usability principles. Retrieved 5/12/2014, from http://www.cc.gatech.edu/~stasko/6750/Talks/03-usabprinc.pdf

Stephanidis C., Akoumianakis, D., Sfyrakis, M., Paramythis, A. (n.d.) User accessibility in HCI: Process-oriented design guidelines and tool requirements. Retrieved 5/12/2014, from http://ui4all.ics.forth.gr/UI4ALL-98/stephanidis1.pdf

Tan, D., Nijholt, A. (2010). Brain-computer interfaces and human-computer interaction. Brain-Computer Interaction: Applying our minds to human-computer interaction. London, Springer-Verlag.

Topi, H., Valachich, J., Wright, R., Kaiser, K., Nunamaker, J., Sipior, J., deVreede, G.J. (2010) IS 2010 Curriculum Guidelines for Undergraduate Degree Programs in Information Systems. Retrieved 5/31/2014 from http://www.acm.org/education/curricula/IS%202010%20ACM%20final.pdf

Welsh, T. (2012). Introduction. The Human-Computer Interaction Handbook, J. Jacko Ed. CRC Press, Baca Raton Fl.

Ying, W., Huiting, Z., Yu, L., Zhang, K., Sun, X., Plocher, T. (2011). Believe What You Hear, Not What You See - Vision Interferes with Auditory Route Guidance in Complex Environment. Human-Computer Interaction. Towards Mobile and Intelligent Interaction Environments Lecture Notes in Computer Science Volume 6763, 2011, pp 346-354

Editor's Note:

This paper was selected for inclusion in the journal as an ISECON 2014 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 2014.

APPENDIX A. – Hot Spots

Figure 2. Previous site (oneextrapixel.com)

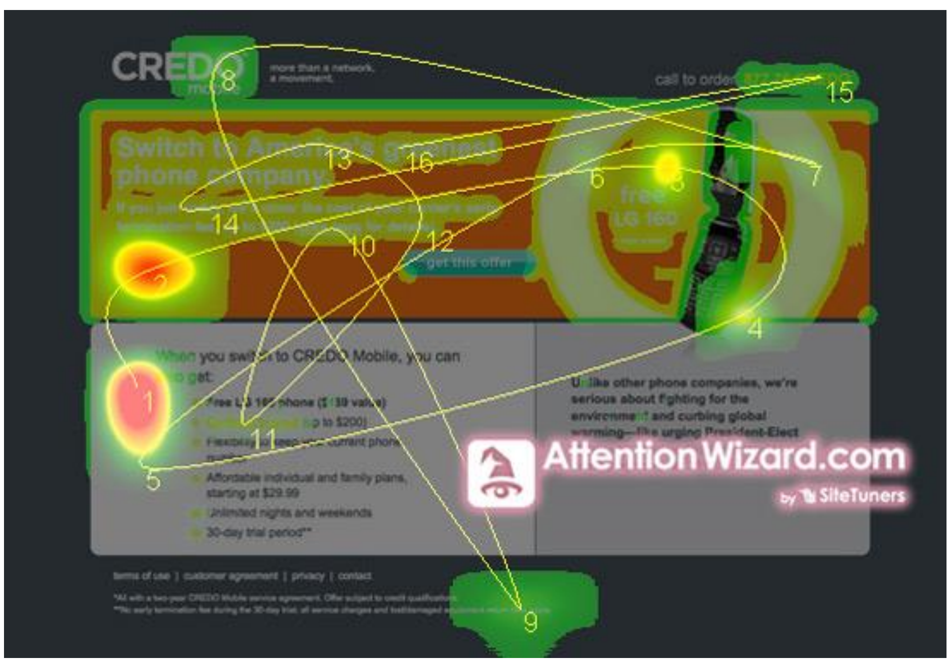


Figure 3. Eye tracking for previous site (oneextrapixel.com).

Figure 4: New site redesigned for hotspots (oneextrapixel.com)

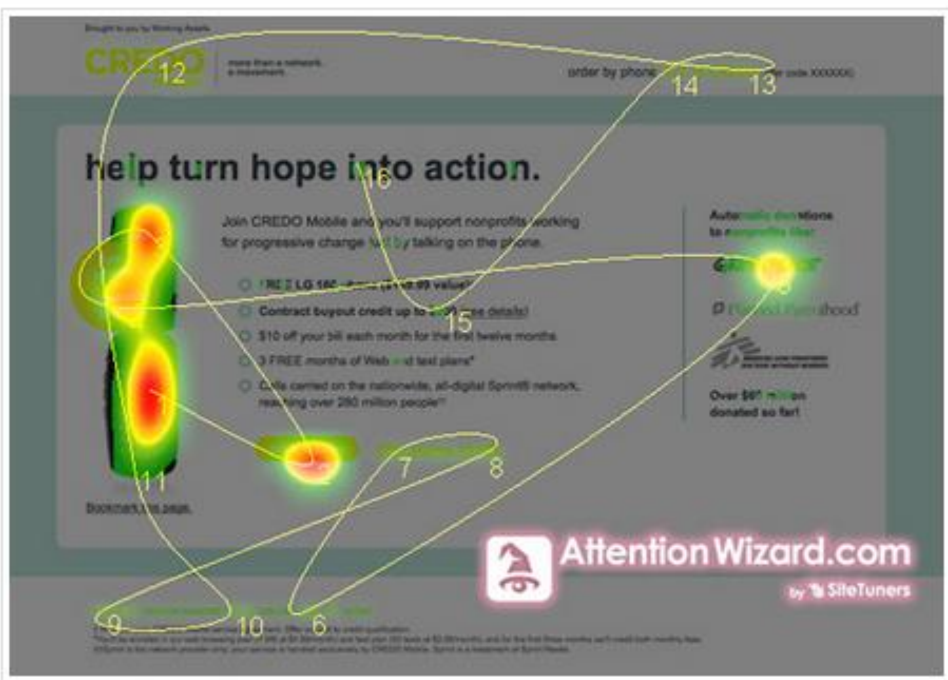


Figure 5 Eye tracking for new site (oneextrapixel.com)

Figure 6: Heat map for 20 users during a page recognition task
(Buscher, Cutrell, Morris, 2009).

APPENDIX B – Potential Syllabus with justification and readings

Table 4 – Detailed topics, justification and additional readings

Week	Topic	Topic details	Justification	Instructor or Student Supplemental Readings and Sample Exercises
Week 1	**Introduction**	• Why study HCI • History of HCI • Importance of interface design – examples that illustrate	Common topic	
Week 2	**HCI : an overview**	• Identifying daily personal interactions with technology • Major principles of HCI	Common topic	***Design of everyday things***: Chapter 1: The Psychopathology of everyday things, found in: Book: "Psychology of Everyday Things", by Donald Norman The perfect brainstorm in the "The Art of Innovation", by Tom Kelley *Demonstrations of examples: Affordance), Mapping, Mental modes*
Week 3	**Psychology of HCI I**	• How does psychology apply to HCI • Human factors • User satisfaction	Suggested topic	**Design: Defining goals:** Book: "Bringing Design to Software", by Terry Winograd Universal Tools: Recruiting and Interviewing (only pages 117-127) Book: "Observing The User Experience", by Mike Kuniavsky Understanding users: Qualitative Research Modeling Users: Personas and Goals Book: "About Face 2.0", by Alan Cooper and Robert Reimann *Demonstrations of examples: Development Cycle, Iteration, Prototyping, Storytelling*
Week 4	**Psychology of HCI II**	• Cognitive Science - Human information processing • Eye tracking • Perceptual-motor interaction	Suggested topic	**Design Prototype:** Making a Paper Prototype Book: "Paper Prototyping", by Carolyn Snyder

		• Attention		
	Task Analysis I	• What is task analysis? • How is task analysis applied? • Use cases • User profile, needs analysis	Common topic	**Design: Evaluation** Designing the Palm Pilot Book: "Information Appliances and Beyond", by Eric Bergman (Ed.) *Demonstrations of examples: Flexibility-Usability Tradeoff, Scaling Fallacy*
Week 5	**Task Analysis II**	• Using task analysis as basis for design • In class exercise	Common topic	**Historical Perspective:** The Xerox Star: An Influential User Interface Design Book: "Human-Computer Interface Design", by Lawrence H. Miller, Jeff Johnson. The Xerox Star: A Retrospective J. Johnson, T. Roberts, W. Verplank, D. Smith, C. Irby, M Beard, K. Mackey (in IEEE Computer, Sept'89) *Demonstrations of examples: Iconic Representation* **The Human Information Processor I** Book: "The Psychology of Human-Computer Interaction", by Card, Moran and Newell *Demonstrations of examples: Fitt's Law, Highlight, Interference Effect, Orientation Sensitivity, Performance Load, Performance vs. Preference*
Week 6	**Interface Design I**	• General design guidelines • Interface design rules • Interaction styles (menus, touch, windows) – interface variability	Common topic	**The Human Information Processor II** Skill Acquisition Book: "Learning and Memory", by J. Anderson *Demonstrations of examples: Chunking, Hick's Law. Recognition over Recall*
Week 7	**Interface Design II**	• Applying psychology to interface design • User goals/perception • Designing for a task	Elaboration on suggested topic	**High Level Theories** Information Processing and Skilled Behavior Book: "HCI Models, Theories, AND Frameworks : Toward A Multidisciplinary Science", By J. Carroll. Chapter 4.

				Demonstrations of examples: Depth of Processing, Feedback Loop
Week 8	**HCI and SDLC/usability engineering model**	• How does HCI fit into the SDLC	Common topic	**Conceptual Models** Cognitive engineering; Direct Manipulation Interfaces Book: "User Centered System Design", by Donald Norman and Stephan Draper *Demonstrations of examples: Cognitive Dissonance, Flexibility-Usability Tradeoff, Mapping, Mental Model, Iconic Representation, Recognition over Recall*
Week 9	**Heuristics/ usability testing**	• Importance of testing • Evaluating without users	Common topic	**Usability Heuristics I** Evaluating the design without users Book: "Task-Centered User Interface Design" *Demonstrations of examples: Gutenberg Diagram, Ockham's Razor, Mnemonic Device, continue in next lecture*
Week 10	**Incorporating user feedback/ iterative design**	• Involving users in testing/designing testing methods	Common topic	**Usability Heuristics II** *Demonstrations of examples: Progressive Disclosure, Recognition Over Recall, Consistency, Visibility Confirmation, Forgiveness* Flash examples: icecream.fla and icecream.swf **Computer Technology** There's more to interaction than meets the eye, Book: "User Centered System Design", by Donald Norman and Stephan Draper
Week 11	**Web design I**	• How does HCI apply to web design • Wireframes	Common topic	**Graphics Design** Organization and visual structure, Book: "Design Visual Interfaces", by Kevin Mullet and Darrell Sano *Demonstrations of examples: Alignment, Closure, Entry Point, Figure-Ground Relationship, Garbage In - Garbage Out, Good Continuation, Hierarchy, Legibility, Proximity, Similarity, Symmetry, Uniform Connectedness, Escaping Flatland,* Book: "Envisioning Information", by Edward Tufte.

Week 12	**Web design II/ evaluating HCI in webpages**	• Appearance/content and graphics • Methods for evaluating HCI in webpage	Elaboration on topic suggested	**Evaluation** Setting the Stage for Discovery, Book: "Science And Its Ways Of Knowing", by John Hatton and Paul Plouffe Examples from the literature: • Stanford Prison Experiment, (Wikipdia entry) • Milgram Experiment (Wikipedia entry) IRB: The role of visual feedback in graphical user interfaces
Week 13	**Using JavaScript/ jQuery/ designing for mobile**	• Screen sizes and HCI considerations • Haptics	Suggested topic	**Qualitative Evaluation** Introduction to Usability Test Facilitation Book: "Paper Prototyping", by Carolyn Snyder Usability Tests Book: "Observing The User Experience", by Mike Kuniavsky
Week 14	**HCI future/current research**	• Incorporating advances in hardware/technology • Future of interfaces/virtual reality/brain-computer interface	Suggested topic	**Qualitative Evaluation** Quantitative analysis of scrolling techniques by Ken Hinckley, Edward Cutrell, Steve Bathiche and Tim Muss, Published in SIGCHI 2002. Growing Up: Moving from Technology-Centered to Human-Centered Products Book: "The invisible computer", by Donald Norman

Cybersecurity Curriculum Development: Introducing Specialties in a Graduate Program

Ali Bicak
abicak@marymount.edu

Michelle (Xiang) Liu
xliu@marymount.edu

Diane Murphy
dmurphy@marymount.edu

Information Technology and Management Science Department
Marymount University
Arlington, Virginia 22207, USA

Abstract

The cybersecurity curriculum has grown dramatically over the past decade: once it was just a couple of courses in a computer science graduate program. Today cybersecurity is introduced at the high school level, incorporated into undergraduate computer science and information systems programs, and has resulted in a variety of cybersecurity-specific graduate programs. However, is that even enough? Is cybersecurity so broad that education needs to be more specialized? Employers want graduates who can hit the ground running: not in the broad field of cybersecurity but in some very specific areas**.**

This paper is structured as follows. First, we will provide a brief overview of the current approaches to cybersecurity education including government standards bodies such as the National Initiative for Cybersecurity Education (NICE) framework, the upcoming changes in the National Information Assurance (IA) Education and Training Programs (NIETP) Center of Academic Excellence (CAE) designation requirements, and the Department of Labor competency model. Second, we will present a framework for curriculum changes, which we use to determine the viability of information technology/information systems (IS/IT) curriculum changes to our departmental educational offerings. We examine relationships with other departments and how cybersecurity is enhanced by other domain knowledge. Then we discuss the three specialties we plan to introduce in the cybersecurity graduate curriculum: cybersecurity data analysis, cyber intelligence, and health care information security and privacy. Finally, the future cybersecurity curriculum directions are presented and discussed.

Keywords: cybersecurity, curriculum development, data analysis, cyber intelligence, health care, security and privacy.

1. BACKGROUND

Our university is a small, private four-year institution in the Washington, DC metropolitan area, close to many Federal government offices. We are accredited by the Commission on Colleges of the Southern Association of Colleges and Schools (SACS) to award degrees at the doctoral, master's and bachelor's levels. We currently offer both undergraduate and graduate programs in IT, with specialties in cybersecurity. These are largely face-to-face programs with a small online component. In addition, we introduced a 36-credit online cybersecurity program in the past two years.

The International Telecommunication Union (ITU) defines cybersecurity as "the collection of tools, policies, security concepts, security safeguards, guidelines, risk management approaches, actions, training, best practices, assurance and technologies that can be used to protect the cyber environment and organization and user's assets. Organization and user's assets include connected computing devices, personnel, infrastructure, applications, services, telecommunications systems, and the totality of transmitted and/or stored information in the cyber environment. Cybersecurity strives to ensure the attainment and maintenance of the security properties of the organization and user's assets against relevant security risks in the cyber environment." (ITU-T, 2014). Despite the emphasis on cyber environment, which makes cybersecurity a subset of the traditional field of "information security", both terms are used interchangeably today due to continuous discovery of security issues and increasing risk in cyberspace. Cybersecurity is a fast growing discipline with new fields and products, such as security incident and event management (SIEM), risk management frameworks, and industry-specific applications, appearing constantly.

As an academic institution, how do we ensure that our degree offerings stay current with workplace needs while ensuring our students have the fundamental knowledge necessary to meet the cybersecurity challenges of tomorrow?

2. EDUCATION VS. TRAINING VS. CERTIFICATION

There is no doubt that to master cybersecurity, professionals need both knowledge and experience as shown in Figure 1 below.

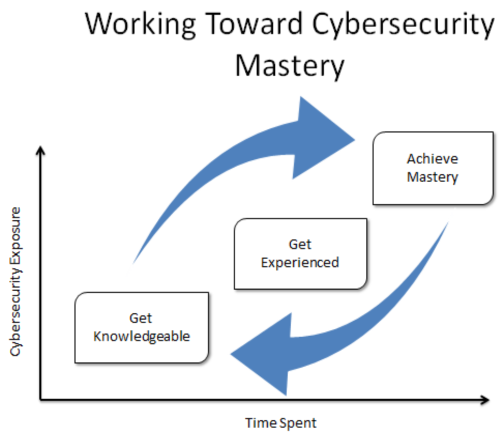


Figure 1: Mastering Cybersecurity knowledge and skills

Both training and education play a role in developing the necessary cybersecurity knowledge base (Woener, 2012). Education can be considered strategic and provides the foundation for the context for security concepts, tools, technologies, etc. and is acquired through formal studies over a period of time. Cybersecurity training may be considered tactical and puts emphasis on explicit skills; therefore, it is usually short term and may be directed to earning a specific certification.

There has been an increasing focus on training and certification in the cybersecurity field, at least, in part, due to the Defense Department Directive 8570, which requires military, civilian and contract personnel who handle cybersecurity for department systems to have certifications appropriate for the job they perform. First issued in 2005, the requirements have been updated three times to show changing requirements (Department of Defense, 2014).

In 2013, the U.S. Department of Homeland Security (DHS) launched the National Initiative for Cybersecurity Careers and Studies (NICCS), an online resource for cybersecurity career, education, and training information in the continuum from high school to graduate levels (niccs.us-cert.gov).

As educators, we must be strategically aware of the evolution of the fast changing cybersecurity discipline and provide programs that prepare our students for the cybersecurity environment of tomorrow, while being aware of the employment needs in the field, including training and certifications.

NICE

An important consideration is the National Initiative for Cybersecurity Education (NICE) framework (csrc.nist.gov/nice/framework/), developed by the National Institute for Standards and Technology (NIST). This organizes some 32 cybersecurity skills and knowledge units in seven categories, recognizing the need both for technical and managerial skills and for a comprehensive knowledge background in implementing a coherent cybersecurity program, as shown in Figure 2.

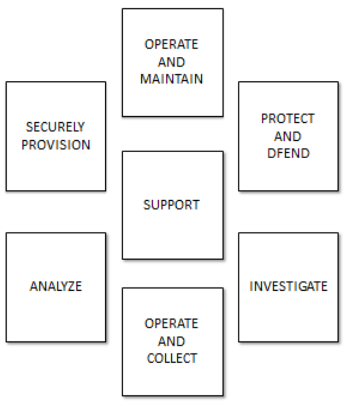


Figure 2. Seven Categories of NICE Framework (Adapted from csrc.nist.gov)

Each of these knowledge categories represents several specialties. For example, the "Operate and Collect" category includes "specialty areas responsible for the highly specialized and largely classified collection of cybersecurity information that may be used to develop "intelligence" leading to the idea of a cyber intelligence component to our program. In addition, the "investigate" category includes "specialty areas responsible for the investigation of cyber events or crimes which occur within IT Systems and networks." Threat reports show that health care is a primary target for cyber criminals and so becomes a consideration for a component of our program (Filkins, 2014). Finally the "analyze:" category includes "specialty areas responsible for highly specialized and largely classified review and evaluation of incoming cybersecurity information", leading to the idea of a cybersecurity data analysis component to our program.

Centers of Academic Excellence

The Colloquium for Information Systems Security Education (CISSE) is one of the leading proponents for cybersecurity education at the higher education level (www.cisse.info). In defining requirements for cybersecurity education, CISSE encourages university programs to receive the National Security Agency/Department of Homeland Security designation of National Center for Academic Excellence in Information Assurance Education (CAE/IAE) (Anderson, 2013). Until very recently, this designation required meeting the criteria defined by Committee on National Security Systems (CNSS). These were essentially the training requirements for specific cybersecurity positions in the defense and intelligence agencies such as the ISSO (Information Systems Security Officer) or systems administrator.

However, these standards are now changing as the National Information Assurance (IA) Education and Training Programs (NIETP) office, the organization that designates CAE/IAE. The designation has been renamed to the Information Assurance/Cyber Defense (IA/CD) and the criteria for designation have been extensively revised "to better reflect the state to which the discipline of IA has evolved since the original publication of the training standards" (www.iad.gov/NIETP). All existing institutions must apply for redesignation by December 2014. The revised NIETP requirements, well aligned with the NICE framework, use a system of knowledge units and focus areas that enable differentiation amongst the higher education institutions by allowing each school to recognize its specific focus areas of research and/or educational offerings. The new standards require programs at 4-year schools (including graduate programs) to cover all the seventeen required and five of the optional Knowledge Units (KUs) to become a CAE IA/CD institution. In addition, the CAE also provides the option for those schools to apply for one or more "Focus Area" designations for their programs. Those focus areas are listed in Figure 3.

Cyber Investigations
Data Management Systems Security
Data Security Analysis
Digital Forensics
Health Care Security
Industrial Control Systems-SCADA Security
Network Security Administration
Network Security Engineering
Secure Cloud Computing
Secure Embedded Systems
Secure Mobile Technology
Secure Software Development
Secure Telecommunications
Security Incident Analysis and Response
Security Policy Development and Compliance
Systems Security Administration
Systems Security Engineering

Figure 3. CAE IA/CD Focus Areas

These suggest that cybersecurity data analysis (listed here as data security analysis) and health care information security and privacy (listed here as health care security) are two of the optional areas that can be supported by our university. While the cyber investigations functional area, as initially documented, focuses primarily on digital forensics, it is envisaged that cyber intelligence will become an important component of this functional area as investigations become more proactive rather than reactive, leading to our specialty in cyber intelligence.

As an institution, we are focusing on the following three focus areas for our upcoming reaccreditation: cyber investigations, data security analysis, and health care security.

Department of Labor Competency Model
The Employment and Training Administration (ETA) of the Department of Labor (DOL) has worked with the Department of Homeland Security and federal agencies that contributed to the NICE framework to develop a comprehensive competency model for cybersecurity. A cadre of technical and subject matter experts from education, government, business, and industry also contributed to the development of the cybersecurity model. (www.careeronestop.org/competencymodel/competency-models/cybersecurity.aspx)

The DOL Cybersecurity Industry Model defines the latest skill and knowledge requirements needed by individuals whose activities impact cybersecurity. Strategically the proposed model incorporates competencies identified in the NICE framework and complements the framework by including both the competencies needed by the average worker who uses technology, as well as the cybersecurity professional. The ETA model (shown in Figure 4) will be updated to reflect future changes to the NICE framework.

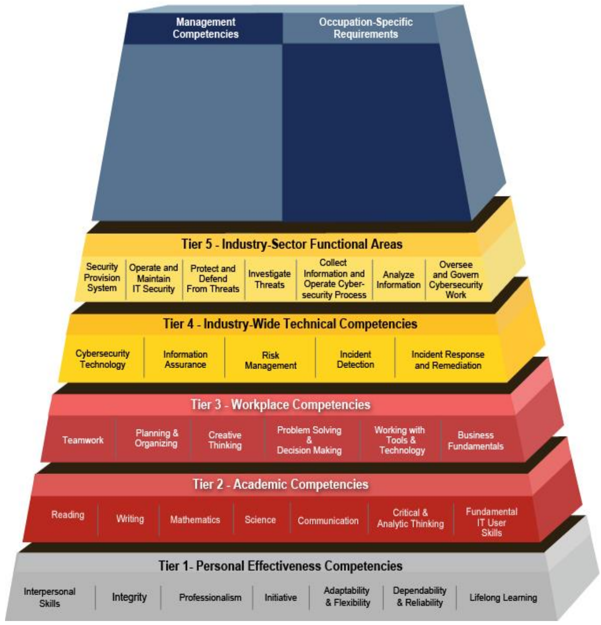


Figure 4. The DOL ETA model (Adapted from www.careeronestop.org)

The model shows general skill requirements as well as industry sector functional areas (Tier 5). These skill areas closely follow the NICE framework. The top tier allows for individual customization in both the managerial and organization specific-space.

Using the interdisciplinary resources of the institution
Institutions have several disciplines that are related to cybersecurity and its application. The CAE IA/CD redesignation requires cybersecurity to be "multidisciplinary within the institution" (www.iad.gov/NIETP). In our university, these disciplines include IT, management, economics, management science, criminal justice, politics, sociology, and forensic and legal psychology. As we consider specialties at the graduate level, we focused our interdisciplinary review to those programs that offer graduate programs in their individual disciplines.

Cybersecurity is located in the business school providing daily contact with the health care management (HCM) faculty as well as the management science faculty. We already have a dual degree in HCM and IT. Further, we have existing courses in health care informatics and the security and privacy of electronic documents. In addition, we are collocated with the forensic and legal psychology program and are collaborating with them in research and curriculum development, particularly for their new intelligence studies specialty.

We have proactively sought conversations about cybersecurity education with these disciplines, and the university in general, and have achieved a high-level of participation in our endeavors.

3. WHEN TO MAKE CURRICULUM CHANGES

The impetus for introducing the above three specialties in our MS in Cybersecurity program was based on input from our Cybersecurity Advisory Group as well as feedback from our students. We then invoked an existing curriculum development model. This "holistic" model provides IS/IT educators with strategic guidance as for "when" to introduce topics on emerging technologies and "how" to incorporate the new knowledge into an existing IS/IT curriculum (Liu & Murphy, 2012). As presented in Figure 5, the original model integrates seven "forces" as a foundation to inform valid decisions as to when changes in the IT/IS curriculum are needed.

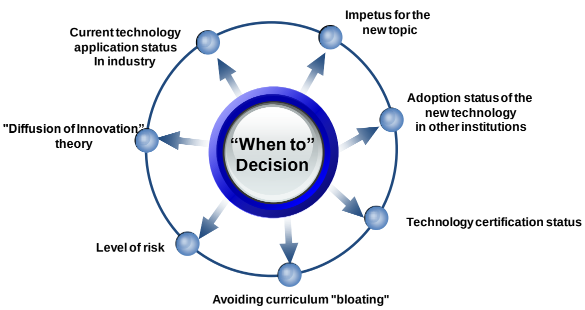


Figure 5. Strategic Model for Making "When" Decisions (Adapted from (Liu & Murphy, 2012))

The first factor is based on the widely cited "Diffusion of Innovation" theory and outlines the macro-level guidelines for the curriculum design, "*we must start early and keep exploring new topics and technologies, with credible leadership (i.e. across the department, the school, and the university) and have a competent team of faculty with the right expertise*" (Liu & Murphy, 2012, p.178)). Our location in the Washington, D.C. area provides us with an enviable adjunct faculty with extensive experience and knowledge.

The second factor is focused on the *current technology application status in industry*. The NICE and NIETP approaches emphasize the need for educators to consider "specialties", as dictated by the government need. DHS also promotes this specialization approach for private sector organizations, particularly those that are responsible for security and resilience of the nation's critical infrastructure elements (www.dhs.gov/critical-infrastructure). Finally, one of the important drivers for adding the data analysis specialty to the cybersecurity curriculum lies in its prevalence in a variety of sectors of industry and government. According to Gartner's survey of IT leadership, 42% of respondents stated they had invested in big data technology, or were planning to do so within a year (Gartner, 2013). This investment in the technology calls for an increase in recruitment of data scientists as has been reported extensively in the press. Our institution is in the Washington D.C. area and this is an important region for data analysis, in part because of the large number of data sources provided by the government and the increased focus of government agencies on data analytics, including in cybersecurity. Adjunct faculty are widely available and we did hire a data scientist as IT faculty in January 2014.

The third factor of the model is the *impetus for the new topic*. The stakeholders playing roles in the curriculum development process include faculty, students, advisory board members, accreditation bodies, and industry leaders (Liu & Murphy, 2012). The aforementioned example of the NIETP office updating its accreditation criteria to keep abreast with the state of the art of the cybersecurity discipline justifies, in part, our proposal of adding the three specialties to the cybersecurity program. In addition, the fact that students in the cybersecurity program have been showing interest in areas of intelligence studies, health care and data analysis is also one important indicator since they are one of major targets in the curriculum development process. Because of our location in the Washington DC metropolitan area, government careers are significant possibilities for our graduates. This job market is important for our students and is one catalyst to introduce specialties to the curriculum.

The fourth factor incorporated in the model is the adoption status of the new technology topic in other institutions. Specializations in cybersecurity at the master's level are beginning to appear across the nation. For example, Ithaca College offers a cyber intelligence specialization in its online MS in cybersecurity program, including specific courses in topics such as cyber intelligence and domestic terrorism end extremist groups. (programs.online.utica.edu/programs/ms-cybersecurity-course.asp).

The availability of a certification in the technology by a reputable organization such as CompTIA or ISC^2 is also considered as an important factor in the model. For example, in information security, the Certified Information Systems Security Professional (CISSP) is considered as a critical certification for faculty and students in cybersecurity in general (Frank & Werner, 2011). The recent introduction of the Health Care Information Security and Privacy Professional (HCISPP) certification is considered an important driver for the health care security specialty.

The sixth factor in the model is a consideration of avoiding curriculum "bloating" This factor was important in our decision to introduce specialties to the cybersecurity program rather than increasing the credit requirements for the program. A course or program that is overloaded will result in high dropout rates and poor grades. An overarching inspection and management process are indispensable for the cohesiveness of the program.

The last factor in the model is the *level of risk*, including the complexity of the highly specific technology focused topics, the long turnover time of the curriculum approval process, and the cost associated with any equipment, software requirements, or library support needs for the new courses. The good relationship kept between the IT department and the other departments/programs, the frequent collaborations among faculty from the IT/IS department and the university curriculum committee, the continuing support from the National Science Foundation (NSF), and the availability of knowledgeable and experienced faculty, will make this curriculum development process smooth.

4. PLANNED CYBERSECURITY SPECIALTIES

The current MS in Cybersecurity program is 36 credits with eight core management and technical courses, three elective courses, and one capstone project. Students electing to take the specialty will take 39 credits with no electives. They will take 4 courses in the specialty area (replacing the 3 electives) and their capstone project must be in their specialty area. This provides them with 15 credits in their specialty area, including 3-credits that apply their specialty topic to either research or to a service project.

Cybersecurity Data Analysis

Cybersecurity data continues to grow within the government and private sector organizations. As the number of cybersecurity incidents grows, computer logs and monitoring tools, across a wide variety of network components and security devices, generate vast amounts of data. This data is mainly used for post-event analysis; once an attack has been detected, the investigation usually starts and the monitoring and log data is analyzed to identify the attack vector and the associated vulnerabilities; perhaps leading to finding who conducted the attack. However, the cybersecurity data could also be used for predictive analysis (cyber intelligence) whether for external attackers or for attacks from insiders.

The research company, Gartner estimates that data collected and stored by enterprise cybersecurity organizations will double through 2016 (Gartner, 2014). In addition, the "Internet of Things" will greatly increase the amount of data collected and stored as sensors and surveillance tools become ubiquitous (Gubbi, Buyya, Marusic, & Palaniswami, 2013).

Another factor to consider is the increasing emphasis on information sharing in cybersecurity. Traditionally, companies have held threat and vulnerability information close, rather than sharing it with each other or the government. However, recent actions, primarily by the DHS, have removed some of the impediments about information sharing particularly with respect to the critical infrastructure (Hayden & Zuckerman, 2012; Information Sharing Environment (ISE), 2013). Data stored in logs and other monitoring tools vary from operating system to operating system and from one vendor's security management tool to another, resulting in variations in what is stored and how it is stored across organizations. This makes sharing detailed attack information for potential threats across the global landscape more difficult. In addition, organizations are combining their internally generated log data with additional information that can be obtained from public sources such as the Whois database and the DNS records. This is resulting in data stores that are not only of high volume but also of high variability.

If monitoring tools are to be used to prevent an attack or to quickly mitigate the effects, then time is of the essence and so data must be analyzed and visualized almost in real-time. As the velocity of the data becomes significant, particularly based on the "Internet of Things", the need for fast analysis is significant in the cybersecurity domain. Finally, the veracity (validity) of data is also a constant issue in cybersecurity, as exemplified by the decline in accuracy in the Whois database (including deliberately incorrect records and the invocation of the "privacy" option by some registrars) and the constant spoofing of source IP addresses.

There is recognition of the cybersecurity data analysis issue by some of the security management vendors and several "Security Information and Event Management" (SIEM) solutions have been introduced. These solutions mainly focus on the real-time analysis of security alerts generated by a range of hardware, software, and software devices in the enterprise network, by compiling and analyzing data in some centralized location (McAfee, 2013). In addition, there have been multiple studies on the use of data science in cybersecurity in the field. For example, in a recent study, the Ponemon Institute found that more than 80% of the organizations surveyed would like to see big data analytics combined with other security initiatives (Ponemon Institute, 2013).

Data science has become a major initiative in business, science and other fields to handle "big data" issues. While a data scientist has a strong background in computer science and mathematics, the major role of the data scientist is to sift through large amounts of data to discover previously hidden insights. As such, the data scientist must have skills in all phases of the data science process including data collection, data storage, data wrangling, data retrieval, data analytics, data mining, and data visualization. More importantly, a recognized component of successful data science is "domain" knowledge: the human intelligence that accumulates within a certain discipline. Domain expertise is necessary to genuinely understand how to apply data science effectively: for instance, to know which data, from all the possible sources, are valuable and which are not. Without the right domain knowledge, much time and effort is wasted in finding the right data instead of solving the most important problem(s).

The four proposed specialty courses include:

- **Data Management for Cybersecurity Information:** this course examines the collection and data and its integration into a database that can be used for subsequent data analysis. Big data techniques will be discussed including effective data collection, data validation, data wrangling, and database loading. Cybersecurity data sources will be used, including those available from the government or Internet sources.
- **Cybersecurity Data Analysis:** this course focuses on the statistical techniques available for different types of data analysis, emphasis being placed on how to apply the techniques rather than mathematical concepts. Students will be required to work with statistical tools and use the R programming language.
- **Cybersecurity Data Visualization:** this course focuses on the communication of results and examines the need to visually represent complex data for management consideration. Reporting, visualization and infographic techniques are explored and students will be expected to use visualization tools with cybersecurity data.
- **Special Topics in Cybersecurity Data Analysis:** this course will focus on new topics in the field and reflects anticipated changes in the cybersecurity data analysis discipline, including new sources of information and new analytical techniques.

Students will be then expected to apply these knowledge units in their capstone projects at the end of their program.

Cyber intelligence

The US Director of National Intelligence has ranked cybercrime as the top national security threat, higher than that of terrorism, espionage, and weapons of mass destruction (Director of National Intelligence, 2014). As today, not only common criminals, but also organized crime rings and nation states are taking a more active role in the cyber arena (Cyber Security Forum Initiative, 2014). Some of these agents have launched very sophisticated and targeted attacks that are hardly detectable (Mandiant Intelligence Center, 2013). A recent report by the PWC and the Software Engineering Institute (SEI) Computer Emergency Response Team (CERT) shows that organizations that have detected such incidents are more likely to employ security capabilities such as vulnerability management, cyberthreat intelligence analysis, intrusion detection tools, and SIEM technologies. (PWC, 2014).

As cybersecurity risks continue to escalate, it is imperative for organizations to move away from reacting (to incidents) to predicting and preventing them (Information Security Forum (ISF), 2012). Cyber intelligence plays a key role in analyzing current cyber incidents in order to predict the emerging threats. "The role of intelligence in any capacity is to collect, analyze, and produce information to provide complete, accurate, timely, and relevant threat assessments to inform decision makers… Effective cyber intelligence will begin to enable predictive, strategic warning regarding cyberthreat activities, mitigate risks associated with the threat, enhance our ability to assess the effects of cyber intrusion, and streamline cyber security into a more efficient and cost effective process based on well informed decisions" (Intellegence and National Security Alliance (INSA), 2011).

NICE Framework defines the required KSAs (Knowledge, Skills and Abilities) for a Cybersecurity Intelligence Analysis (under Category of "Protect and Defend" and the specialty area of "Computer Network Defense") as "Uses information collected from a variety of sources to identify, analyze, and report events that occur or might occur within the network in order to protect information, information systems, and networks from threats." These are very much aligned with the traditional intelligence cycle, which is a circular and repeated process to collect and convert data into intelligence; and has the following five steps: planning and direction, collection, processing, production and dissemination (Department of Defense, 2013). Similarly, SEI has defined a cyber intelligence framework and an overview of this is presented in Figure 6. (www.sei.cmu.edu/about/organization/etc/citp-summary.cfm).

Figure 6: SEI Cyber Intelligence Framework (Adapted from sei.cmu.edu)

Considering the SEI framework (SEI Emerging Technology Center, 2013), the coursework for a specialty in cyber intelligence should cover the following KSAs.

- **Data gathering and examination:** Exploring a variety of manual and automated data sources, collecting information, aggregating and analyzing it through automated intelligence techniques.
- **Functional and strategic threat analysis:** Functional analysis focuses on answering the "what" and "how" of cyberthreats whereas strategic analysis aims to answer "who" and "why." Both analyses require advanced content knowledge and strong critical thinking skills.
- **Reporting for decision makers:** Dissemination of intelligence to decision makers through concise and accurate technical reports, and coordinate sharing of information with all involved parties.

Therefore, the cyber intelligence specialty will require the students to complete following four courses:

- **Intelligence Studies: this course examines the traditional fields of intelligence and examines how some of these tried and tested tools and techniques (including counterterrorism) can be applied to the cybersecurity field.**
- **Cyber intelligence: the course includes open-source intelligence (OSINT) tools, tactics, techniques,**

procedures (TTP) and indicators of compromise (IOC), motivation of adversaries, cyberprofiles and behaviors, situational awareness. The course also includes the legal parameters for cyber intelligence.

- **Investigating cybercrimes: the course includes techniques such as the legal parameters for pursuing and prosecuting cybercriminals, communicating and collaborating with law enforcement and legal teams, as well as global considerations.**
- **Cyber counterintelligence: this course includes both defensive and offensive cyber counterintelligence techniques and strategies, reverse deception, cyber espionage, insider threats, and the use of data to predict potential incidents.**

The capstone project will include a detailed case study and the application of these techniques to the particular scenario.

Health Care Information Security and Privacy

The health care industry is facing an uphill battle in its efforts to detect and prevent cyber-attacks, and reduce and stop the loss or theft of protected health information (PHI) or patient information. According to a recently-published analysis of Standard & Poor's (S&P) 500-stock index companies by BitSight Technologies, health care and pharmaceutical companies rate lowest among finance, utilities, and retail in terms of security performance (BitSight Technologies, 2014). Another survey conducted by the Identity Theft Resource Center (ITRC) revealed that medical-related identity theft accounted for 43% of all identity thefts reported in the United States in 2013, which surpassed identity thefts involving banking and finance, the government and the military, or education (Identity Theft Resource Center, 2014). Ponemon Institute has conducted an annual benchmark study on patient privacy and data security since 2010. The third annual study reported that some 94 percent of medical institutions have been victims of a cyber attack (Ponemon Institute, 2012). Various reports show that cyberthreats are not declining. The most recent annual study discloses that criminal attacks on health care systems have risen a startling 100 percent since their first annual report in 2010, resulting from inadequate resources such as funding, technologies, trained personnel and expertise (Ponemon Institute, 2014).

Furthermore, "with the push to digitize all health care records, the emergence of healthcare.gov and an outpouring of electronic protected health information (ePHI) being exchanged online, even more attack surfaces are being exposed in the health care field" (Filkins, 2014, p.2). In April, 2014, the Federal Bureau of Investigation (FBI) warned health care providers that their cybersecurity systems are lax compared to other sectors, thus, may be more vulnerable to attacks by hackers searching for Americans' personal medical records and health insurance data, "The health care industry is not as resilient to cyber intrusions compared to the financial and retail sectors, therefore the possibility of increased cyber intrusions is likely" (Finkle, 2014).

The alarming facts of cyberthreat in the health care field reveal "how far behind industry-related cybersecurity strategies and controls have fallen" (Filkins, 2014, p.2). Obviously, there has been a great demand from the industry for health care IT personnel with adept security skills and knowledge, an important component of our curriculum adoption model.

As the technology certification status is another important factor in the adoption model, current certifications available in health care security and privacy by reputable organizations are examined below.
Two recent examples are:

- CompTIA Healthcare IT Technician: (certification.comptia.org/getCertified/certifications/hittech.aspx)
- AHIMA: Certified in Healthcare Privacy and Security (CHPS®): (www.ahima.org/certification/chps)

In addition, the International Information Systems Security Certification Consortium ((ISC)^2), the leader in educating and certifying information security professionals, launched a new certification, Health Care Information Security and Privacy Practitioner (HCISPP). The HCISPP is a demonstration of knowledge by security and privacy practitioners regarding the proper controls to protect the privacy and security of sensitive patient health information as well as their commitment to the health care privacy profession. The HCISPP Common Body of Knowledge (CBK) consists of the following six domains (www.isc2.org/hcispp-domains/default.aspx):

- Health care industry;
- Regulatory environment;
- Privacy and security in health care;
- **Information governance and risk management;**
- Information risk assessment; and
- Third-party risk management.

Taking both the CAE/ID focus areas and the available certifications, including the (ISC)[2] HCISPP CBK ((ISC)[2], 2013) into consideration, the four proposed specialty courses are listed as follows:

- **Introduction to the Health Care Industry**: this first course covers the basics of the health care environment including types of organizations, health insurance, coding, as well as function, structure, and financing of health care. It includes third-party relationship (e.g., vendors, data sharing, etc.) and health data interoperability and exchange.
- **Health Care Security and Privacy Policy**: this course focuses on applicable regulations, policies and compliance frameworks related to health information (e.g., data breach regulations, ePII, generally accepted privacy principles, etc.). Students will develop policies for the type of threats faced by facilities.
- **Privacy and Security of Electronic Documents**: this course focuses on the management of large volumes of documents (from images to test results, from prescriptions to insurance claims) in health care and discusses tools and techniques to protect security and privacy
- **Risk Management in Health Care**: The course discusses how organizations manage information risk through security and privacy governance. It includes risk identification, risk assessment, and mitigation actions. It also covers how to manage third party risks.

The final capstone project will focus on the application of security and privacy control to health care data, by either working with a case study or by service learning**.**

5. CONCLUSIONS

Cybersecurity is a fast growing discipline and there is a need for more educated and trained personnel who have a mastery of the subject matter. Educators need to take a strategic role in preparing this workforce and the need for cybersecurity specialties is one such strategy. Based on a holistic model, we have carefully examined the seven factors, which influence our decision to offer three specialties in our MS in Cybersecurity program: cybersecurity data analysis, cyber intelligence and health care security and privacy. As a small private university, we have looked outside our discipline to find resources that can supplement our technical cybersecurity knowledge and skills from other faculty teaching in related topics, and whose students may be interested in some of these overlapping courses.

6. REFERENCES

(ISC)[2]. (2013). *HealthCare Information Security and Privacy Practitioner Exam Outline*.

Anderson, K. (2013). Building a Better Information Assurance Degree and Promoting Cybersecurity Education. *ISSA Journal, 11*(5), 20-23.

BitSight Technologies. (2014). Will Healthcare be the next Retail? Retrieved from http://www.bitsighttech.com/

Cyber Security Forum Initiative. (2014). Executive Cyber Intelligence Report. (June 3, 2014). Retrieved from http://www.tripwire.com/state-of-security/government/executive-cyber-intelligence-report-june-3-2014/

Department of Defense. (2013). Joint Publication (JP) 2-0: Joint Intelligence. (October 2013). Retrieved from http://fas.org/irp/doddir/dod/jp2_0.pdf

Department of Defense. (2014). DoD 8570.01-M, Information Assurance Workforce Improvement Program, Change 3.

Director of National Intelligence. (2014). Worldwide Threat Assessment of the US Intelligence Committee. (January 29, 2014). Retrieved from http://www.dni.gov/index.php/newsroom/testimonies/203-congressional-testimonies-2014/1005-statement-for-the-record-worldwide-threat-assessment-of-the-us-intelligence-community?tmpl=component&format=pdf

Filkins, B. (2014). Health Care Cyberthreat Report: Widespread Compromises Detected, Compliance Nightmare on Horizon: SANS Institute.

Finkle, J. (2014). Exclusive: FBI warns healthcare sector vulnerable to cyber attacks. Reuters. Retrieved from http://www.reuters.com/article/2014/04/23/us-cybersecurity-healthcare-fbi-exclusiv-idUSBREA3M1Q920140423

Frank, C., & Werner, L. (2011). *The Value of CISSP Certifocation for Educators and Professionals.* Paper presented at the Information Security Curriculum Development Conference, Kennesaw, GA

Gartner. (2013). Gartner Survey Finds 42 Percent of IT Leaders Have Invested in Big Data or Plan to Do So Within a Year. Retrieved from http://www.gartner.com/newsroom/id/2366515

Gartner. (2014). Predictions 2014: Garner's Predictions for the Year Ahead. Retrieved from http://www.acq.osd.mil/dsb/reports2010s.htm

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions. *Future Generation Computer Systems 29*(7), 1645-1660

Hayden, M., & Zuckerman, M. (2012). Cybersecurity Task Force: Public-Private Information Sharing. Bipartisan Policy Center. Retrieved from http://bipartisanpolicy.org/library/report/cybersecurity-task-force-public-private-information-sharing

Identity Theft Resource Center. (2014). 2013 ITRC Breach Report. Retrieved from http://www.idtheftcenter.org/ITRC-Surveys-Studies/2013-data-breaches.html

Information Security Forum (ISF). (2012). Data Analytics for Information Security, from Hindsight to Insight. Retrieved from https://www.securityforum.org/research/

Information Sharing Environment (ISE). (2013). 2013 Annual Report to the Congress. Retrieved from http://www.ise.org/annualreport

Intellegence and National Security Alliance (INSA). (2011). Cyber Intelligence: Setting the landscape for an emerging discipline. (September, 2011). Retrieved from http://www.insaonline.org/i/d/a/resources/Cyber_Intelligence.aspx

ITU-T. (2014). X.1205, Overview of cybersecurity. Retrieved from http://www.itu.int/en/ITU-T/studygroups/com17/Pages/cybersecurity.aspx

Liu, X., & Murphy, D. (2012). *Tackling an IS Educator's Dilemma: A Holistic Model for "When" And "How" to Incorporate New Technology Courses into the IS/IT Curriculum* Paper presented at the Proceedings of the Southern Association for Information Systems Conference, March 23rd-24th, 2012, Atlanta, GA.

Mandiant Intelligence Center. (2013). Mandiant Intelligence Center Report: APT1: Exposing One of China's Cyber Espionage Units. (February 18, 2013). Retrieved from http://intelreport.mandiant.com/Mandiant_APT1_Report.pdf

McAfee. (2013). SIEM: Keeping Pace with Big Security Data. CIO Magazine White Paper.

Ponemon Institute. (2012). The Third Annual Benchmark Study on Patient Privacy and Data Security. Retrieved from http://www.ponemon.org/news-2/45

Ponemon Institute. (2013). Big Data Analytics in Cyber Defense. Ponemon Institute Research Report. Retrieved from http://www.ponemon.org/library/big-data-analytics-in-cyber-defense

Ponemon Institute. (2014). The Fourth Annual Benchmark Study on Patient Privacy and Data Security. Retrieved from http://www.ponemon.org/blog/fourth-annual-benchmark-study-on-patient-privacy-and-data-security

PWC. (2014). US cybercrime: Rising risks, reduced readiness-Key findings from the 2014 US State of Cybercrime Survey. (June, 2014). Retrieved from http://www.pwc.com/en_US/us/increasing-it-effectiveness/publications/assets/2014-us-state-of-cybercrime.pdf

SEI Emerging Technology Center. (2013). Cyber Intelligence Tradecraft Project, Summary of Key Findings. (January 2013). Retrieved from http://www.sei.cmu.edu/library/assets/whitepapers/citp-summary-key-findings.pdf

Woener, R. (2012). Security Education vs Training. *Information Security, 14*(4), 6-7.