Redesigning the Traditional Introductory Computer Course: A Pretest/Posttest Analysis

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Abstract

This paper presents an analysis of the impact of introductory information systems course concepts on student performance. A survey instrument comprising of 60 items, mapped to various knowledge domains, was developed and conducted in the beginning (pretest) and at the end (posttest) of the semester. The difference in performance of the students from pretest and posttest was calculated for every performance indicator (in aggregate) for the course and each item individually. Improvement in performance (more than 10% from the pretest score) was recorded for all of the knowledge areas. Also, the posttest feedback form included a question asking the students to rate the relevance of the topics introduced in the course (open-end type of questions.) Implications are discussed and future research directions presented.

Keywords: pretest, posttest, introductory information systems, course redesign, digital literacy, flipped classroom

1. INTRODUCTION

What is the importance of a core introductory information systems course at the college level? Traditional college-level courses designed to teach computer literacy are in a state of flux. Today's students have high rates of access to computing technology and computer ownership, leading many educators and decision makers to conclude that students already are computer literate and thus computer literacy courses are not necessary in today's college curriculum. (Ciampa, 2013). There is even a school of thought that a core computer course does not even need to be discussed since incoming freshmen have already learned computer competencies at the high school level. Close to 100 percent of students use word processing and utilize the Internet for coursework (Nataraj, 2014).

However, what would happen if the course was redesigned to fit what the students feel is important to them? Would students grasp the important subjects they need? Higher education institutions are taking to redesigning high-enrollment introductory computer courses to improve student learning outcomes and student success (Ariovich & Wallace, 2014). The purpose of this study is to determine a student's computer knowledge upon course entry and see if there is a difference in college student's scores as measured by the difference in pretest and posttest scores of students at the end of a college-level introductory computing class. It will also discuss what can be done to increase the effectiveness of an introductory course at the college level (possibly redesigning the course.)

The research questions that this study addresses are:
1. What topics should be covered in depth in an introductory computer course?
2. What is the best approach for "teaching" computer concepts?
3. What software/technology tools should be covered in an introductory computer course?
4. What types of assignments should we be using (case studies, research papers, lab, etc.)?

The rest of this paper is organized as follows. The next section presents an analysis of research in the area of an introductory computer course at the college level as well as definitions of computer literacy and digital literacy. The section following the literature review presents the methodology used for this study including data collection and data analysis. The discussions from our findings from our data are presented in the section followed by the conclusions for this study.

2. LITERATURE REVIEW

The review of the literature will define computer literacy and digital literacy. It will also discuss the importance of preparedness of incoming freshmen as well as discuss what can be done increase the effectiveness of an introductory computer course at the college level.

Computer Literacy

In today's society, it is generally accepted that one of the keys to being successful is to be computer literate or to have a certain level of technical competence. There has been much research trying to identify basic computer literacy skills that are needed for all college-level students. Incoming freshmen students complain about having to take an introduction course because they feel like they already "know how" to use computers (Hindi, Miller, & Wenger, 2014). "Students often consider themselves proficient in the use of modern technology, but it appears to be the "wrong" type for academic purposes," according to Ratliff (2009). They can chat, Twitter, or social network, but they cannot attach a document to an email. They neglect to use punctuation, rarely use standard formatting, and include slang or acronyms (Ratliff, 2009).

Morris (2011) sought to explore the relationship between computer self-efficacy and computer proficiency. "Colleges and universities face the daunting task of assessing the computer proficiency of incoming students and training them in the computer skills they will need to be successful in college and beyond" (p. 1). Morris' dissertation concluded that college-age students, although part of the Generation Y, do not possess the computer proficiency skills that are required in the university and college level.

The literature strongly supports the idea that students are coming to college without the skills they need to be considered computer proficient. However, faculty expects students to have intermediate to expert skill levels in the application and Internet domains (Stone, Hoffman, Madigan, & Vance, 2006). Morris (2011) found that computer proficiency scores were low for entering students, which was not expected since these Generation Y (generally students born from the early 80s to the early 2000s) students are perceived to have a high computer literacy by definition.

Many faculty speculate that students today are more computer literate than their peers several years ago. Prior research suggests that students are not leaving high school with the knowledge necessary to function in either academia or the workplace (Stone, Hoffman, Madigan, & Vance, 2006).

A lack of basic Information, Communications and Technology (ICT) skills may render an incoming freshman unable to perform the fundamental tasks required at the university level (Stone, Hoffman, Madigan, & Vance, 2006). ICT skills use technology as a tool to research, organize, evaluate, and communicate information; use digital technologies, communication/networking tools, and social networks appropriately to access, manage, integrate, evaluate, and create information to successfully function in a knowledge economy; and apply a fundamental understanding of the ethical/legal issues surrounding the access and use of information technologies (Partnership for 21st Century Skills Framework, 2010). High school courses tend to cover computer concepts such as printers, the Internet, hard drives, operating systems, virus protection, and display units (Hindi, Miller, & Wenger, 2014). Many high schools today teach their students how to surf the web as well as build web pages (Holmes, Switzer, & Csapo, 2002).

Computer capabilities are essential for success in the business world. Technological advances necessitate learning, maintaining, and upgrading of computer-related knowledge (Hindi, Miller & Wenger, 2014, p. 143). Computer literacy involves conceptual knowledge related to basic terminology (including social, ethical, legal, and global issues) and skills necessary to perform tasks in word processing, database, spreadsheets, presentation graphics, and basic operating systems functions (Hindi, Miller, & Wenger, 2014, p. 143).

Digital Literacy

Digital literacy has been defined in the following ways: (1) the ability to use digital technology, communication tools or networks to locate, evaluate, use and create information (Digital Strategy Glossary of Terms); (2) the ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers (Pool, 1997); and (3) a person's ability to perform tasks effectively in a digital environment…literacy includes the ability to read and interpret media, to reproduce data and images through digital manipulation, and to evaluate and apply new knowledge gained from digital environments (Jones-Kavalier & Flannigan, 2006).

Casey & Bruce (2011) define digital literacy as the awareness, attitude and ability of individuals to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analyze and synthesize digital resources, construct new knowledge, create media. Digitally literate people can communicate and work more efficiently, especially with those who possess the same knowledge and skills. Research around digital literacy is concerned with "learning how to effectively find, use, summarize, evaluate, create, and communicate information while using digital technologies, not just being literate at using a computer" (Plunkett, 2010).

Students who are not digitally literate are less effective in their studies and less employable (JISC, 2012). Digital literacy must be taught. According to Helen Beetham from the JISC Developing Digital Literacies Program, digital literacy stands at "the intersection between digital knowhow and academic practice" (JISC, 2012, p. 2). Many students entering universities today have a high level of exposure to digital technologies and media. However, they are not prepared to cross the bridge between personal and academic use of technology (JISC, 2012). Students today are certainly exposed to and immersed in digital media, but their ability to use information technology to solve common business and real-world problems is frequently over-estimated (Murray & Perez, 2014).

Changes Needed for Introductory College Courses

An introductory course at the college level should address the following content areas: computer hardware, communications technology, operating systems, ethics and security, information literacy, productivity tools, web authoring and publishing, software development, and emerging technologies. The course content should also examine economic, social, legal, and ethical issues as well as accessibility. According to Hindi, Miller, and Wenger (2014), an improved and extended coverage of database and spreadsheets might be warranted in a college level computer course. A college level computer literacy course should emphasize problem solving skills utilizing technology. Weber (2015) posits that the key to a good paying job is Microsoft Excel. Sixty-seven percent of middle-skill jobs demand proficiency with these tools.

Microsoft (2015) offers new digital literacy courses in the following areas: (1) Computer basics (learn the fundamentals of computing, the components of a computer, operating system basics, and how to use a mouse and a keyboard; (2) The Internet, Cloud Services, and World Wide Web (learn how to connect to people, information, and resources around the world, using Web sites, search engines, and e-mail programs); (3) Productivity Programs (games, demos, and interactive guides help you to quickly learn the basics of word processing, spreadsheets, presentations, and databases; (4) Computer Security and Privacy (Identify and protect your computer and data from threats, and learn the ethical and legal issues related to Internet usage); and (5) Digital Lifestyles (learn how new digital technologies like smart phones and digital cameras are creating new career opportunities and shaping the world we live in) (Microsoft Digital Library, 2015).

The purpose of the introductory computing course should be to ensure that students achieve an essential understanding of IT infrastructure, learn to use the Web and other network resources, protect their digital data and devices, and become technology users and consumers (Sanghera, 2013). Some general goals of the course should be as follows: (1) identify and discuss the four main functions of computer hardware: input, processing, output, and storage; (2) identify and describe major hardware components; (3) identify, describe, and use communications and networking technology; (4) describe the major operating system functions; (5) identify and discuss computer ethics and security issues; (6) demonstrate searching, validation, and evaluation of information; (6) identify, discuss, and use categories of application software; (7) design and create a web pages using XHTML; (8) identify and discuss emerging technology; and (9) understand IT impact on society. These skills will serve as the foundation for more advanced skills, which might include items such as spreadsheets, databases, image analysis programs, computer graphics, or geographical information systems.

By making minor adjustments to the content covered, students will have exposure to all elements of information technology that will be used in their academic, professional, and personal lives. The issues discussed will make living and working in an "information society" easier.

3. DATA COLLECTION AND ANALYSIS

A survey instrument of 60 questions was developed. These questions were mapped to the seven domain areas of knowledge covered in the introductory course of information systems. Every domain area is represented by 7 or 8 items in the test. The test items were developed with the objective of assessing commonly used knowledge in information systems but ensuring that these topics are covered in the course at some point in time.

The survey was conducted in the beginning of spring semester in four sections of the introductory information systems course. These students were informed that this test was assessing their general proficiency in the concepts developed in the course. The students were not informed that they will have the same test for finals. Students were awarded some preliminary points for completing the test in class. In the final exam (posttest), some open ended questions were also given.

The test was conducted in four sections of the introductory course (pretest and posttest). There are a total of 90 responses from the same. Every student had to take the survey as their final exam so response rate was 100%. Students were provided with scantrons for the test. The answers were analyzed using DataLink software which pulls the data from scantron reader. This software generates a detailed item analysis report, which was exported in Excel for further analysis. Questions mapped to individual knowledge domain area were grouped together to generate an average percentage of correct answers. The results of the analysis are presented below.

Results

Table 1: Details of pretest result

Total Possible:	60		**Average:**	33.6	56.05 %
Highest Score:	47	78.33 %	**Median:**	34	56.67 %
Lowest Score:	18	30.00 %	**KR20:**	0.702115	

Table 2: Details of posttest result

Total Possible:	60		**Average:**	39.9	66.47 %
Highest Score:	49	81.67 %	**Median:**	40.5	67.50 %
Lowest Score:	22	36.67 %	**KR20:**	0.6935899	

Table 3: Comparison of pretest and posttest scores for each knowledge domain (See Appendix B)

4. FINDINGS

As Table 2 suggests, there is no significant improvement in student performance in all seven major knowledge domains. There is definitely an improvement in performance of students in all the domains. There is no clear emergent picture about the topics that are perceived more or less useful by the students. During the post test, students were given a feedback form with eight (8) open ended questions to provide information regarding the structure of the course, assessments offered, level of relevance and difficulty of topics. In this section, we will discuss the findings as related to each research question.

RQ1: What topics should be covered in depth in an introductory computer course?
The posttest feedback form included a question asking the students to rate the relevance of the topics introduced in the course. The topics were listed as taught; students rated each topic on a scale ranging from: *1-Highly relevant, 2-Relevant, 3-Relevant, 4-Neutral, 5-Somewhat irrelevant, 6-Irrelevant and 7-Highly irrelevant*. Forty-seven percent of the respondents identified "Knowledge of Software" as a "Highly relevant" topic. The Knowledge of Software topic covered an Introduction to Microsoft Excel and Access as the two major software topics in the course. There was a 10.88% increase in performance from the pre-test to the post-test in this area.

On the feedback form, 40% of the respondents shared that the Excel labs were challenging but useful. Twenty-three percent stated that Microsoft Access was their least favorite topic as they felt the tool has no relationship to their majors and future careers. It is important to note that majority of the students in the four sections are Business majors. These students will use Microsoft Excel in their upcoming courses including Business Statistics, Economics and Finance. Forty-five percent of the respondents found "The Impact of IT at the personal, social and cultural level of life" topic as "Relevant" to their learning process. As seen in Table 3 (see Appendix B), there is an 11.22% growth in performance as related to this topic.

The results showed that the systems development life cycle topic was seen as the least relevant or "Highly irrelevant" as students noted that they did not see the applicability of this topic to their majors. Although the increase in knowledge as shown from the pre to post-test indicates some growth, it is less than 10%.

RQ2: What is the best approach for "teaching" computing concepts?
The results from the feedback form indicated that students overwhelmingly preferred labs and discussions to the options of lecture and chapter assignments. In a classroom with digital natives, it is important for instructors to tailor their teaching approach to meet the needs of the students (Vaughan, 2014). Three percent of students indicated an interest in teachings that were tailored to their individual majors, to highlight the relevance of the course to their academic careers. This response supports the authors' notion that topics should include more hands on, real world applicability as seen in the students' preference for "Knowledge of Software" and "The Impact of IT at the personal, social and cultural levels of life", and lab work.

RQ3: What software/technology tools should be covered in an introductory computer course?
The students favor an increase in the introduction of software tools in the course. They also indicated a need to introduce tools and software used for the development of everyday technologies. Twenty-five percent of the respondents indicated a lack of interest in Microsoft Access as "they do not see the relevance of the tool in their future careers". The authors suggest a high level introduction of tools used to develop the systems and applications used by students today. It is not uncommon for students to ask questions about application development tools and the possibilities of developing applications that could address personal, societal and cultural challenges. In two of the four sections, students were given a final project to design a technological solution for a problem at the personal, societal or global level.

The students indicated this project as their favorite portion of the course. The students were required to research the elementary tools needed to develop their technological solutions and 100% of the students indicated that they would have enjoyed learning more about tools that are used to develop the applications used today. It is understood that providing access to some tools would be expensive for many schools, but most students found open source alternatives, or trial versions of the well-known development tools. An example would be a group using AppMakr and Mobincube to develop an application to bring Sign Language experts around the globe in a community that supports individuals interacting with individuals who have hearing difficulties.

RQ4: What types of assignments should we be using in the introductory computer course?

The introduction to information systems course is a core course (or in some institutions, a General Education course) which "services" students from all disciplines with a diverse understanding and interaction with technology. The issue instructors' face in this course includes providing challenging yet balanced assessment techniques to capture the interest of students who are focused on their various majors (Pregitzer & Clements, 2013). The students indicated interest in the question asking "Is there anything you would like to share about this course?" In response to this question, 59% of students suggested more practical projects. There are ample opportunities to introduce creative classroom assessment techniques to keep students engaged and motivated.

Discussions and Recommendations

The pre and post test scores show an increase in knowledge based on performance scores. The feedback form sheds more light to students looking forward to more hands-on projects in the course. The responses could suggest a possible introduction of a "flipped classroom". A flipped classroom suggests that students receive the teaching portion of the course via taped lectures or videos and use the teaching portion of the course to apply learned concepts via hands-on activities (Steed, 2012). This approach could increase student-instructor feedback, support the students need for problem/project based learning.

The authors propose a flipped classroom technique to give students more time for discussion and in-class activities while keeping the lecture piece as a part of the course via recorded lectures, readings, videos, and multimedia presentations (see figure 1 in Appendix A). The flipped classroom concept encourages course designers and instructors to integrate hands-on activities to the lectures to ensure a seamless transfer of knowledge.

The flipped classroom approach requires assignments that complement the idea of using classroom time in more hands-on projects and application of theoretical concepts discussed in the lecture sessions. In summary (table 4, see Appendix C), the feedback suggests a need for the redesign of the course to further encourage students to critically think of computing in their personal, academic, and career endeavors.

All the contributions of this study are represented as recommendations in Table 4 (see appendix C). The introductory information system is a core course at this University and for many non-IS majors one of the only IT courses that they take in undergraduate curriculum. It is essential that this course is catered to the learning needs of freshmen of today's generation. A flipped classroom approach provides the opportunity to create a solid theoretical background in IS concepts and ample opportunities for students to apply this knowledge in form for a hands-on activity.

Educators have to be creative in addressing the technology needs of future workforce, if not as a producer of technology, as a major consumer of technology. Use of projects that allows student to be better engaged in the class is important. Topics of such projects should potentially excite the students. This study contributes to information systems pedagogy research by proposing means to keep introduction to information systems course in the curriculum. The future research studies that could stem from this study are actually redesigning the course in a flipped classroom manner and measuring the change in student performance in various knowledge areas. An experimental study comparing the performance of students in a traditional classroom with one that uses just hands-on projects could be an interesting follow-up study.

A major limitation of this study is the bias that comes with a single source of data for research. All the participants were from one particular university and hence the results might not be representative of multiple perspectives. In future pursuits, we need to collect data from different types of schools across the nation, and measure the performance of students in introductory information systems course using various teaching modalities.

5. CONCLUSION

This study explores the ways to redesign and teach introductory information systems course in undergraduate curriculum in a way that enhances student participation, learning and performance. A pretest/posttest was designed to measure student performance in seven knowledge areas covered in this course and student feedback on these topics was solicited through open ended questions. The results suggest that traditional classroom methods are not perceived to be very useful by students. This is also indicated in non-significant improvement in student performance from pretest to posttest scores. A flipped classroom approach with more attention to hands-on learning is proposed. Implications were drawn and limitations presented. Future research stemming from this work is also discussed.

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APPENDIX A

Technology Today Presentations

- Students will research the latest technologies with a release date of no earlier than a year. Students must identify and categorize the selected technology as a software or hardware. The presentation allows students to learn more about modern day technologies, develop communication and research skills. Instructors can ask students to present technologies related to their major or hobby. Students will learn more about hardware and software and apply the learned concepts to their findings.

Design a Solution

- This exercise encourages students to think of problems faced on a personal, societal or global scale that can be solved with the intervention of technology. The students will describe the problem, affected people and provide a solution to the problem. The students will design a solution by detailing the basic technologies to develop the technology. This project allows students to practice the System Development Life Cycle in a way that is clear and concise. The students see themselves as potential problem solvers.

Technology and My Major

- Students will research and present technologies that are relevant to their majors and future careers. This exposes them to the tools that they will use in their future courses and careers.

Figure 1 Proposed Assessment Types for Introduction to Information Systems Course

APPENDIX B

Table 3: Comparison of pretest and posttest scores for each knowledge domain

Domain topic	**Items**	**Pretest Correct responses**	**Pretest Average %**	**Posttest Correct response**	**Posttest Average %**
Basic knowledge about the Internet (e.g. Network, fastest connection)	Question 1	85	81.54%	83	85.70%
	Question 2	63		74	
	Question 3	85		81	
	Question 4	65		77	
	Question 5	75		74	
	Question 6	70		70	
	Question 7	87		87	
	Question 8	70		78	
Key components of information technology equipment (e.g. memory chips, types of printers, binary)	Question 9	18	35.87%	22	51%
	Question 10	23		30	
	Question 11	23		63	
	Question 12	24		43	
	Question 13	14		14	
	Question 14	27		57	
	Question 15	69		81	
	Question 16	53		43	
	Question 17	17		25	
	Question 18	62		86	
Knowledge of hardware (e.g. input, processing, output, storage)	Question 19	78	63.46%	83	71.70%
	Question 20	35		53	
	Question 21	30		27	
	Question 22	70		75	
	Question 23	72		82	
	Question 24	38		35	
	Question 25	79		84	
	Question 26	65		83	
Knowledge of software (e.g. operating systems and applications such as Excel and Access)	Question 27	41	52.71%	40	63.59%
	Question 28	85		86	
	Question 29	66		80	
	Question 30	23		46	
	Question 31	50		67	
	Question 32	13		9	
	Question 33	54		65	
	Question 34	56		70	
Systems development life cycle (e.g. requirements analysis, programming, water fall, flow chart etc.)	Question 35	52	47.36%	67	56.04%
	Question 36	28		38	
	Question 37	83		84	
	Question 38	15		22	
	Question 39	40		46	
	Question 40	26		31	
	Question 41	61		69	

Tools to solve problems at business and societal levels (e.g. security, DBMS, data warehouse)	Question 42	56	46.64%	81	59.04%
	Question 43	36		63	
	Question 44	19		22	
	Question 45	36		44	
	Question 46	53		67	
	Question 47	48		70	
	Question 48	41		59	
	Question 49	43		29	
	Question 50	53		62	
	Question 51	66		74	
	Question 52	21		20	
Impact of information technology at personal, social, and cultural level of life (e.g. copyright, social media, digital divide)	Question 53	58	72.29%	76	83.51%
	Question 54	87		90	
	Question 55	86		91	
	Question 56	55		63	
	Question 57	75		86	
	Question 58	29		37	
	Question 59	64		77	
	Question 60	78		88	

APPENDIX C

Table 4: Summary of Recommendations

Research Question	Recommendations
1. What topics should be covered in depth in an introductory computer course?	Based on feedback and performance, students benefited from hands-on topics in the course. Focusing on software and hardware gives the students an insight into the applications and tools they interact with on a daily basis. These topics seemed to be more relevant to the students.
2. What is the best approach for "teaching" computing concepts?	The course has both lectures and hands-on activities. We suggest a flipped classroom technique encourages students to take more responsibility for their learning, and because the in-class activities are directly tied to the lectures. Research has shown an increase in student engagement, and achievements using this teaching approach (Vaughan, 2014).
3. What software/technology tools should be covered in an introductory computer course?	The students have shown interest in Microsoft Excel due to its use in their other courses. It is important to include other software/technology tools that can be used for technology creation especially more user friendly tools.
4. What types of assignments should we be using in the introductory computer course?	The course needs more hands-on activities, problem solving activities that relay concepts to students in a more practical manner. Proposed assignments include "Technology Today Presentations", "Design a Solution" project, and "Technology and My Major."