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Students' Perceived Technology Competency and Learning Outcome: A Comparative Study

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Abstract

This paper addresses students' understanding of information technology and reports the results of a study that assessed and compared students' perceptions to their competency levels in understanding and in the use of information technology. The researchers conducted a study with 401 student participants that were enrolled in sixteen introductory sections of a business computer systems course. The results indicate that students' perceptions of their knowledge were by far higher than their actual measured competency. These results were consistent with other researchers who have demonstrated that students' ability to use technology does not equate to proficiency or understanding of technology. There exists a very large gap between students' perception of the general uses of technology to its actual comprehension through demonstrated application of technology.

Keywords: Technology competency, Career readiness, Information technology

1 Introduction

With the rapid advances in technology over the past three decades, we have witnessed a shift from the industrial age to an information age throughout the world. With this paradigm shift, as technology has moved into all sectors of our society, its disruptive attributes have changed the ways in which society interacts, communicates, functions, and works (Arazoza, 2015; Tasi, 2003). This paper addresses students' self-perception to their actual understanding of Information Technology; identifies various areas that effects technology readiness; and reviews studies regarding the teaching and use of technology within secondary and higher education. As part of this study, a set of research questions were developed and, the researchers administrated two different categories of surveys to answer those questions. The first category evaluated the perception of students in their proficiency level of technology and the second category evaluated their actual competency and knowledge in the use of the same technology. The different areas covered in the survey instruments included: general knowledge of computing in business, web pages, spreadsheets, and databases. The students were asked to complete surveys both before and after a specific technology was presented. In this way, students' perception and their actual understanding of each topic material were measured, and the results were analyzed and compared.

2 Literature Review

2.1 Information-Based Economy and Digital Divide

The economy in developed countries had shifted from a manufacturing toward an information-based economy within the past few decades. As manufacturing becomes more capital intensive, according to the U.S. Bureau of Labor and Statistic, there has been a reduction of 7.5 million manufacturing jobs from 1980 to 2017 in the United States alone. While a drop of only 2.0 million occurred between 1980 and 2000. The large majority of 5.5 million job losses occurred much more recently during the period of 2000 to 2017 (Hernandez, 2018). Contrasting this decline in labor capital, data and information have become a vital commodity within all organizations. Drucker (1999) suggests that the most valuable asset of a twenty-first century organization will be its knowledge worker, while the most important asset in the twentieth century was its production equipment. In the information age, as work becomes more specialized, knowledge intensive, and highly data-and-information driven, the traditional organization has been forced to evolve to cope with this information explosion and the everchanging business environment (Tsai, 2003). New terms such as "information organizations," "virtual organizations," "learning organizations," and "network organizations" are being used to replace the traditional hierarchical and structured organizations of the past century.

In an information-based economy, the demand for higher-skilled and better-educated labor has increased, and organizations now reward these specializations and expertise by paying employees better wages and salaries (Kock et al. 2008). A growing body of literature has identified technology skills as an important factor for student's job placement and success as the new workforce requires different skill sets, such as problem-solving, abstract thinking, collaborating with others, and requiring more technological training and education (Bowles, 2013; Brown et al., 2018; Danesh et al., 2015).

Within the last two decades, the majority of literature concerning student's readiness for the job market identified technology literacy, and specifically the digital divide aptitude, as one of the main factors that attribute to an individual's technology competency. Arazoza defines this digital divide as "the technology gap that exists between different social and economic classes," for without having access, certain social groups could possibly fall behind in accumulating the knowledge needed to be ready for the challenges that the information and digital job market requires (Ara- zoza, 2015). The concept of the digital divide has been thoroughly studied globally, within many individual countries, and across various social and economic groups. However, this digital gap is centered on two crucial problems: the access to the technology and the access to the proper training or education (Chetty, Aneja, Mishra, Gcora, & Josie, 2017). As a global phenomenon, it compasses the lack of financial capital to properly create the infrastructure needed to provide adequate access in developing nations. A report published by G20-Insight in 2017 identified the higher cost of technology infrastructure for poorer communities and the limited access to proper training as the two main challenges fueling this digital divide (Chetty et al., 2017). This may encompass developing needs from the supply of electricity to having proper technology infrastructure, lack of access to proper hardware, and limited opportunities for educational training. This is ever important, as Bowles (2013) argues that digital training and education are a crucial for harnessing the benefits in investment made by private and public sectors in the area of the information and communications technology infrastructure.

In addition, in a survey presented by the Lee Rainie, director of the Pew Research Center identifies five factors that affect various groups in using technology and inequality of the digital divide (Caumont, 2013). The survey found and identifies that the lower and unequal use of the internet among various populations. The study suggests that the population with higher-age, lower-income, lower-educational level, those living in rural communities, individuals with disabilities, and the Spanish speaking population are less likely to use the internet (Caumont, 2013). Even though there has been an increase in the use of digital communication and computer technology throughout the world within the last decades, and even though more businesses and communities are embracing technology, there has still been a widening in the digital divide and literacy. This inequality is creating a barrier for communities and individuals to seize the socio-economic opportunities that are afforded by the new digital economy (Bowles, 2013).

2.2 Secondary and Higher Education

For students to have the proper skill sets and be ready for the job market, the educational systems provide the greatest role. At the K-12 level in the United States, the federal government protects the constitutional rights of students and teachers and mandates certain special education programs. Meanwhile, the local and state governments are responsible for establishing policies, standards, and guidelines for secondary education's curriculum. While there have been trends in establishing a national standard for certain subjects, these standards vary widely among various states and local school municipalities based on their socioeconomic levels and available funding for each district.

States also vary broadly in their requirements for secondary education. A majority of state guidelines and requirements concentrate on using technology to facilitate the learning environment and teaching strategies rather than what technology competency students should gain while attending high school. The requirements also include guidelines for certain career readiness training, such as business education or computer science which each school districts can use to implement its own curriculum for graduation. The Pennsylvania Department of Education in their Academic Standards for Business, Computer, and Information Technology (BCIT, 2013) covers the importance of technology education. These standards describe the strategies and define the essential skills and knowledge that students need to attain at different grade levels as they advance through the educational system. The standards attempt to include various stakeholders such as educators, parents, and community leaders to act as partners in the student learning process. BCIT states "The standards provide the targets for instruction and student learning essential for success in all academic areas, not just business classrooms. Although the standards are not a curriculum or a prescribed series of activities, school entities will use them to develop a local school curriculum that will meet local students' needs" (BCIT, 2013).

While a minimal number of technology classes in business education or computer science are often taken by students in various focused paths, they are also considered electives as such students may opt to choose a non-technology class to full-fill the credit requirements (i.e. Business communication, Career Paths, etc.). In Pennsylvania, like the majority of other states, students can possibly graduate without taking a computer or technology class at the high school level. As students graduate from high schools and enter the college, the amount of technology literacy can vary substantially among them. At this time, students have experience in using email, the internet, a variety of social media sites, smartphones, and a plethora of application programs, causing them to perceive themselves as knowledgeable in using technology. However, does the ability to use these state-of-the-art technologies, software application programs, and communication medium channels constitute being technologically competent, and will the students be able to navigate their college careers and eventually enter the job market using these skills?

At most institutions of higher educations, in addition to the courses required within their major, the students are also required to take a set of common general education courses, plus the courses required by their school of studies (i.e. art and sciences, business, education, etc.). The term general education or the common curriculum has a different meaning in different institutions. This designation usually refers to the common set of courses that all students of the institution must undertake and pass in other to fulfill the graduation requirements. However, while it is required by accreditation bodies that colleges and universities offer some form of general education curriculum, there is no explicit requirements as to the exact courses that should be offered within that curriculum (Warner & Koepppel, 2009).

Similar to the high schools, while technology or computer courses are recommended, the majority of the colleges and universities do not require any specific technology course within their general education curriculum. One of the exceptions to this is the schools or colleges of business that usually require at least one dedicated technology course for all majors within the college as part of their college core requirements. Association to Advance Collegiate Schools of Business International (AACSB) is an accrediting agency that has served as standardization and accrediting agency for business programs at the college level since 1916. According to AASCB, there are 862 business colleges and institutions in the United State and internationally who have earned AACSB accreditation as of Jan- uary 2020. AACSB Eligibility Procedures and Accreditation Standards for Business Accreditation state the following technology agility skills as part of their curriculum content for the degree program and learning goal (AACSB 2018):

- Evidence-based decision making that integrates current and emerging technologies, including the application of statistical tools and techniques, data management, data analytics and information technology throughout the curriculum as appropriate
- Ethical use and dissemination of data, including privacy and security of data
- Understanding of the role of technology in society, including behavioral implications of technology in the workplace
- Demonstration of technology agility and a "learn to learn" mindset, including the ability to rapidly adapt to new technologies
- Demonstration of higher-order cognitive skills to analyze an unstructured problem, formulate and develop a solution using appropriate technology, and effectively communicate the results to stakeholders

The above guideline reaffirms the importance of technology mind set, training, and provides the general parameters that should be used within the curriculum in a business college. In addition, it also identifies various specific competencies such as being able to use tools and application programs to perform data analytics, data management, and statistical analysis.

2.3 Perceived verses Actual Competency

There are two dimensions in assessing students' competencies. First is self-perceived knowledge and the second is actual knowledge. A variety of studies have been performed in assessing either the self-perception or actual competency of subjects, students, or employees in regard to a specific proficiency (Kaminski, et al., 2009; Langer & Knefelkamp, 2008). This study evaluates and compares both dimensions. In an educa- tional environment, assessment can be described as the process of evalu- ating individuals' ability and performance to the learning objectives of a course or in a larger and national scale it can be used as a process of eval- uating groups' performances in order to monitor and hold schools and teachers responsible for delivering standard curricula (Kaminski et al., 2009; Verger, Parcerisa, & Fontdevila, 2018).

While there are a multitude of assessments, evaluations, and learning models currently available and are being practiced in the educational settings, the majority of them can be grouped into two separate categories, self-perceived assessments and competency-based assessments (Humberg et al. 2019; Langer & Knefelkamp, 2008). Self-perceived assessments have been used as the subjects evaluate their own skills in learning or for professional development. In contrast, competency-based assessments generally use a form of oral or written evaluation instrument to evaluate subjects' performances, understanding, or knowledge to the learning objectives of a course or training (Kaminski et al., 2009). John and Robins (1994) in their accuracy and bias in self-perception study indicate while there exists some individual differences in self-perceptions, overall individuals have a higher bias in judging their own skills and performance levels and ranked their own performance higher and more positively than when ranked by other group members and peers (John 1994). Therefore, subjects were not as competent in their skills as they believed.

The researchers ponder if students in an institution of higher education have a higher self-perception of their knowledge than their actual knowledge and would their self-perception induce biases as some other studies suggest? Overall the disparity in technology skills; the importance of technology training; the perception and competency improvement of the subjects prior and post instructions; and the effects of self-perception on individual judgment were all import themes of the previous studies. So to further investigate the aforementioned assumptions, the following four questions were derived based on the previous studies and guidelines provided by accreditation institutions:

- Q1: What are the perceptions and competency levels of students using productivity software prior and post instruction?
- Q2: What are the perception and competency levels of students of generic technology concepts at the start and end of a course?
- Q3: Does the perception and competency level of students for a particular IT component increase after instruction?
- Q4: Do the perception and competency levels correlate with each other?

The researchers studied students' competencies of these questions in an introduction to technology course that contained exposure to technology concepts and instruction to different types of productivity application software throughout the semester to measure students' learning and outcome.

3 Methodology

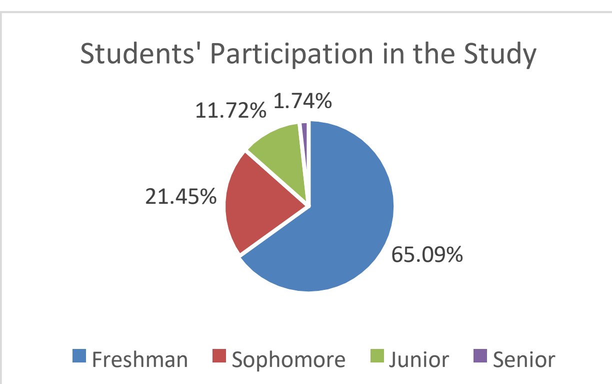
The goal of this study was to compare the students' perception to their competency in their ability to understand basic technology concepts and in the use of various popular productivity software packages used in business before and after taking an introduction to a business computer systems course.

To accomplish this task, two questionnaires were designed based on previous research selected from the literature review and AACSB guidelines for technology agility within the business schools' curriculum. The questions in the first questionnaire were designed to capture the students' perception prior to and post taking an introduction to technology class that contained exposure to technology concepts and instruction to different types of productivity software while the second questionnaire was to access the students' competency in understanding the same materials. Both questionnaires were comprised of four different sections. Each section was comprised of 8 to 12 questions. The four sections in the first questionnaire included: surveying students' perception in:

- understanding and using Excel spreadsheet package
- understanding the basic terminologies and using Access database management system
- general conceptual knowledge in technology and computing in business
- knowledge in using Hypertext Markup Language in designing basic web pages

The second questionnaire included the same sections, but the questions were designed to test and assess students' competency in the same four areas. Each section of both questionnaires was administrated once at the beginning and again at the completion of the coverage of its corresponding topic during the semester.

Fig 1. Subjects' participation by class:



After securing the approval of the University Institutional Research office, each section of the questionnaire was administrated to fourteen different sections of an introductory level business computer systems course during two semesters. Each of the fourteen sections had an enrollment of 27 – 35 students. A total of 401 students participated in the study. Of the students participating in the study, 65.2% were freshmen, 21.4% were sophomore, 11.7% Junior, and 1.7% identified themselves as seniors. At the completion of the experiment, data were combined into Excel files. Partial or incomplete data were discarded, and the final data were imported into SPSS program for final analysis to:

1. Compare students' perception about their knowledge to their actual knowledge prior to the coverage of the topics.
2. Compare students' perception about their knowledge to their actual knowledge post coverage of the topics.
3. Compare the improvements of perception and actual in the beginning to the end of the semester.

4 Data Analysis and Discussion

The course utilized a combination of lectures, hands-on applications, online practice modules, and take-home projects throughout the semester. The following four sub-sections provide the topics covered; namely spreadsheet software and concepts, database software and concepts, computer concepts, and web design and concepts. In each of the four subsections, an analysis was performed reviewing the data that students provided at both the start and end of the topic material covered. Students provided perception data utilizing a ten point Likert scale survey. In addition, students provided actual competency by answering multiple choice questions.

4.1 Spreadsheet Software and Concepts

The spreadsheet section of the course utilized Microsoft Office Excel and provided students with the following topics: entering and formatting data, writing basic formulas for calculation using relative and absolute addressing, order of precedence of operators, utilizing basic statistical functions (Sum, Max, Min, Count, CountA, Average, Mean, Mode), logical functions (If, Countif, Sumif), financial functions (FV, PMT) and other functions such as Vlookup, and Hlookup. The final topics included creating and formatting different types of graphs and charts.

Table 1 depicts that students had the lowest initial scores in cell referencing - using relative and absolute addressing within formulas- followed by built-in-functions which were 37.93% and 44.90% respectively. The highest improvement gains were also observed in learning cell referencing 51.29% followed by built-in functions with 50.61%. While charting has the highest initial scores 58.57%, it had the lowest gain of 23.56%. Table 2 depicts that students perceived themselves as most unlearnt in the cell referencing and built-in functions topics with average scores of 3.00 and 3.47 respectively. After instruction, the cell referencing and built-in functions topics improved drastically with average scores of 7.09 and 7.18 respectively. These two topic areas represent the largest percentage change of 136.33% and 106.92%. The other two categories, editing, and basic formula and built-in functions also show average scores improvements at 50.10% and 54.86% respectively. The researches point out that the trends in both actual and perceived competency are similar. Namely, all topics depict that post scores are higher and that the largest percentage changes occurred in the cell referencing and built-in functions topics.

T-tests were utilized to examine differences between the mean scores for the pre and post evaluation. The results of T-tests were statistically significant at $p < 0.001$ for all questions.

TABLE 1: Actual Spreadsheet Competency

Actual Spreadsheet Competency			
	% Correct Pre (n=312)	% Correct Post (n=249)	% Change
Editing & basic formula	54.20%	78.67%	45.14%
Cell referencing	37.93%	57.38%	51.29%
Built-in functions	44.90%	67.63%	50.61%
Charting	58.57%	72.37%	23.56%

TABLE 2: Perceived Spreadsheet Competency

Perceived Spreadsheet Competency			
Topics	Average Pre (n=314)	Average Post (n=233)	% Change
Editing & basic formula	5.06	7.57	49.60%
Cell referencing	3.47	7.17	106.63%
Built-in functions	3.38	7.11	110.36%
Charting	5.25	8.09	54.10%

4.2 Database Software and Concepts

The database portion of the course introduced students to creating databases using single and multiple tables utilizing Microsoft Access and the design view; setting up primary keys, foreign keys, and relationships among tables; creating queries, forms, and reports. The query design screen was used to generate queries.

Table 3 and Table 4 clearly depicts that students had a low competency in database concepts prior to taking the course but improved drastically after instruction. Table 3 depicts that students showed the lowest initial understanding in creating queries at 24.47% but by the end of the semester this competency had the highest percentage of gain of 102.98%. In addition, the relationship topic incurred a large increase at 65.49%. Creating basic tables, forms, and reports had the lowest gains with almost a similar outcome, namely 32.47% and 34.76% respectively. Table 4 depicts the students' perception of database concepts with the average pre instruction scores ranging from 2.74 to 3.15, which indicates students as most unlearnt. After instruction, the perceived percentage increases are dramatic and range from 139.23% to 176.64%. The researches point out that the trends in both Table 3 and Table 4 are dissimilar. Specifically, the percentage increases of the perceived are much higher than the actual, which further supports the concept discussed in the literature review that students believe they know more than they actually do.

T-tests were utilized to examine differences between the mean scores for the pre and post evaluation. The results of T-tests were statistically significant at $p < 0.001$ for all questions.

TABLE 3: Actual Database Competency

Actual Database Competency			
	% Correct Pre (n=333)	% Correct Post (n=363)	% Change
Relationship	32.49%	53.77%	65.49%
Creating queries	24.47%	49.67%	102.98%
Creating forms/reports	46.52%	62.69%	34.76%
Creating tables	47.37%	62.75%	32.47%

TABLE 4: Perceived Database Competency

Perceived Database Competency			
	Average Pre (n=341)	Average Post (n=323)	% Change
Relationship	2.74	7.58	176.64%
Creating queries	3.04	7.44	144.74%
Creating forms/ reports	3.11	7.44	139.23%
Creating tables	3.15	7.81	147.94%

4.3 Computer Concepts

This section of the course provided students with four primary components, namely overview of hardware and software, the role of information systems in the business environment, responsibilities of those involved, and the potential future trends in information technology and the implications these trends may have on the business world. The results for both students' actual competencies and their perceptions are extreme. The data listed in Table 5 depicts that students demonstrated the smallest positive improvement of 24.78% in the computing basics category. Similarly, the emerging technologies category part of the survey showed the highest improvement at 33.95% which could be attributed to students using and interacting with some of these technologies on a daily basis. However, ethics and privacy categories had a negative increase which could be attributed to the lack of students' interest, inconsistent or lack of coverage of the subject by some faculty during the semester.

Table 6 depicts students' perceived concept competency and it is interesting to note that the categories of privacy/security and ethics in computing depict a positive increase of 19.85% and 51.40% respectively. In contrast, these categories had a negative increase in the actual concepts competency of -9.73% and -9.33% respectively. This result further supports the concept discussed in the literature review that students believe they know more than they actually do.

T-tests were utilized to examine differences between the mean scores for the pre and post evaluation. The results of T-tests were statistically significant at $p < 0.001$ for categories computing basics and emerging technologies but not for questions regarding ethics and privacy in Table 5.

TABLE 5: Actual Computer Concepts Competency

Actual Concepts Competency			
	% Correct Pre (n=293)	% Correct Post (n=227)	% Change
Computing Basics	46.33%	57.81%	24.78%
Emerging Technologies	39.92%	53.48%	33.95%
Privacy/Security	87.37%	78.87%	-9.73%
Ethics in Computing	57.33%	51.98%	-9.33%

TABLE 6: Perceived Computer Concepts Competency

Perceived Concepts Competency			
	Average Pre (n=296)	Average Post (n=245)	% Change
Computing Basics	5.93	7.04	18.71%
Emerging Technologies	3.18	6.13	92.77%
Privacy/Security	6.08	7.43	19.85%
Ethics in Computing	4.28	6.48	51.40%

4.4 Web Design

The web design section of the course involved instructors using a hands-on approach to cover designing and developing World Wide Web pages using Hyper Text Markup Language (HTML). HTML tags for displaying text, images, internal/external links, and tables were introduced. While some students had previous familiarity with HTML authoring software, the majority indicated that this was the first time they were using HTML tags and a text word processor to design web pages.

The primary deliverable of this component of the course was that students designed and created a website consisting of several web pages. Students were able to link the pages together and learned to utilize the university's web server to store and manage their pages on the Internet. Tables 7 and 8 depict that using HTML tags to design and develop a website had positive and very similar gains, namely 80.90% and 89.32%.

The researchers noted that students enjoyed using HTML and spending hands-on time to create their own websites and many students noted that this was one of their favorite parts of the course.

T-tests were utilized to examine differences between the mean scores for the pre and post evaluation. The results of t-tests were statistically significant at $p < 0.001$ for all questions.

TABLE 7: Actual Web Design Competency

Actual Web Design Competency			
	% Correct Pre (n=302)	% Correct Post (n=289)	% Change
Web Design Using HTML	38.59%	62.12%	80.90%

TABLE 8: Perceived Web Design Competency

Perceived Web Design Competency			
	Average Pre (N=295)	Average Post (N=251)	% Change
Web Design Using HTML	3.56	6.74	89.32%

4.5 Overall Competency

Tables 9 and 10 depict the summary of percentage change for all four categories before and after class room coverage of each topic in both actual and perceived competency. The overall class average percentage change for actual and perceived is 44.08% and 81.99% respectively. Of particular interest is that the trends in actual and perceived competencies are identical. At the completion of the course the results for actual competencies for both web design and database components have the highest increases of 80.90% and 58.93% respectively. Similarly, the perceived competencies with web design and database have the highest increases of 89.32% and 151.50% respectively. As with the previous two topic categories the results for actual competencies for both spreadsheet and computer concepts also depict high increases of 42.65% and 10.00% respectively. Similarly, the perceived competencies both spreadsheet and computer concepts also have average increases of 74.59% and 19.01% respectively.

Therefore, the data does support the claim that students do improve in these specific areas after classroom instruction. The data also depicts that students' perception of their own improvement is much greater than their actual improvement. These results further support the concept discussed in the literature review that students believe they know more than they actually do.

In addition, T-tests were utilized to examine differences between the mean scores for the pre and post evaluation. The results of t-tests were statistically significant at $p < 0.001$ for all questions except the questions regarding ethics and privacy.

TABLE 9: Overall Actual Competency Improvements

Overall Actual Competency Improvements			
	% Correct Pre	% Correct Post	% Change
Spread Sheet	48.90%	69.01%	42.65%
Database	37.71%	57.22%	58.93%
Computer Concepts	57.50%	60.50%	10.00%
Web Design and HTML	38.59%	62.12%	80.90%
Overall Class Average	44.83%	61.83%	44.08%

TABLE 10: Overall Perceived Competency Improvements

Overall Perceived Competency Improvements			
	Average Pre	Average Post	% Change
Spread Sheet	4.29	7.49	74.59%
Database	3.01	7.57	151.50%
Computer Concepts	4.05	5.27	19.01%
Web Design and HTML	3.56	6.74	89.32%
Overall Class Average	3.72	6.77	81.99%

5 Conclusion

Different skill sets are needed to be prepared and productive in careers created by an information-based society. In this study, digital divide, secondary, and college education were identified and reviewed as the important factors precursor to entering the workforce. Undergraduates enter college with a diverse socioeconomic and educational background competency. Incorporating technology education into the curriculum is vital to ensure success throughout secondary and college education and the future career endeavors of students. In addition, while technology is utilized in all curricula, students could possibly navigate secondary and col- lege education without taking any required technology course.

This study compared students' perceptions to their competency level in assessing their technology knowledge prior to and post taking an introduction to technology course at the college level. The analysis of data indicated that when assessing self-perception, overall students ranked their own skills higher than their actual proficiencies. A review of other literature suggests the result was aligned with other researchers who questioned the accuracy, bias, and precision of self-perception (John 1994). The study also suggests that in the different areas of instruction, both the self-perception and competency improved by the end of the training for the various concepts covered during the semester.

6 Limitations and Future Study

The measure of actual competency was realized using a multiple-choice survey instrument. Therefore, students could guess the correct answer. Also, the actual competency survey utilized multiple choice questions with either four or five choices. In contrast, the perceived competency used a consistent ten point Likert scale across the four categories of study. Therefore, the scales for actual vs perceived competencies were different so percentages were utilized in the analysis.

The students and the course in this study were from the college of business, to further study the importance of including computer and technology courses in the curriculum, collaborative and comparative studies between researches in different institutions of higher education or among different colleges within the same university could be conducted. In addition, longitudinal studies to measure the increase in students' technology skills at the freshman and senior years during their education at the institution would further provide a more accurate measurement to students' technology improvement and their ability to better be prepared for the challenges of the information-based careers.

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