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Workforce readiness: A study of university students' fluency with information technology

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ABSTRACT

This study with data collected from a large sample of freshmen in 2001 and a random stratified sample of seniors in 2005 examined students perceived FITness (fluency with Information Technology). In the fall of 2001 freshmen at a medium sized research-one institution completed a survey and in spring 2005 a random sample of graduating seniors completed a similar survey. The surveys measured the student's self-reported proficiency in basic information technology knowledge and skills such as word processing and presentation software as well as more complex applications such as digital audio. We found a significant increase in perception of skills in presentation software and browsers and although both groups reported low skill levels, a significant decrease in perception of skills in database, web animation, programming, desktop publishing, digital video, and video audio. Although one might assume an undergraduate would indicate an increase in information and communication technology skills, this study found that often student's perceptions of ability decline. However this decrease may be due to their increased awareness of the skills needed in the workforce.

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1. Introduction

Information technology has quickly become a crucial part of our global society, as in the United States technological advances seem to occur almost daily. "The Workforce Readiness Report Card" (Klein, Cavanagh, Kay, & Meisinger, 2006) states "The future workforce is here – and it is woefully ill-prepared for the demands of today (and tomorrow's) workplace" (p. 9). With a declining population and baby boomers retiring, Klein predicted a lack of necessary skills needed to thrive in the new technology-based economy. In fact, the Partnership for 21st Skills (2007) indicates that "Profound and accelerating changes in the economy makes it imperative for the nation to be much more strategic, aggressive and effective in preparing students to succeed and prosper." Yet, according to the Digital Economy (2003), among 55 US industry sectors education is the least technology-intensive enterprise. Institutions of higher learning are justly concerned and many are seeking ways to demonstrate the readiness of their graduates. The purpose of this study was to determine how "FIT" (fluent with information technology) graduating seniors, at a mid-sized research-one institution, perceived themselves to be. In addition we were able to compare the responses from graduating seniors to the responses of freshman five years earlier to help us determine if there was a change in perception. Although when measuring perception underachievers tend to over-state and over achievers tend to under-state their skills, this information combined with recommendations for incorporating technology literacy skills across the curriculum can help institutions to better prepare their graduates. The theoretical framework provided by the FIT model (National Research Council, 1999) drove the design of this study as well as the analysis of the data.

There are contradicting beliefs about student FITness. The first is that high school students entering universities know more than faculty about computers and information technology. The second is those incoming freshman do not have the information technology skills needed to be successful and faculty do not have the time to teach basic skills in addition to their course content. One might presume that students perceive themselves as more FIT after completing an undergraduate education.

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1.1. What is FITness?

In 1997 the National Research Council (NRC) asked the Computer Science and Telecommunications Board (CSTB) to address this issue (Lin, 2000). CSTB devised the concept of fluency with information technology (FITness) to measure the ability of an individual to handle information technology. While computer literacy is defined as a focus on computer skills, and more specifically the ability to use a few computer applications (Lin, 2000), FITness requires that people understand information technology well enough to apply it productively in work situations and in their daily lives, to recognize when information technology may assist or hinder the achievement of goals and to adapt to changes in and the advancement of information technology (NRC, 1999). The NRC stated that:

> People fluent with information technology are able to express themselves creatively, to reformulate knowledge, and to synthesize new information. It entails a process of lifelong learning in which individuals continually apply what they know to adapt to change and acquire more knowledge to be more effective at applying technology to their work and personal lives (p. 2).

The committee constructed a set of intellectual capabilities, fundamental/foundations concepts and contemporary skills that society should know and understand about information technology (Dougherty, Kock, Sandas, & Aiken, 2002a). *Intellectual capabilities* surpass simply having the intellectual ability to manipulate typical hardware and software applications, but involve the ability to apply information technology in complicated situations (NRC, 1999). According to Dougherty et al. (2002b), users should exploit their capabilities to use information technology whenever possible. The NRC (1999) compiled a list of 10 important capabilities that individuals must possess: (1) engage in sustained reasoning; (2) manage complexity; (3) test a solution; (4) manage problems in faulty solutions; (5) organize and navigate information structures and evaluate information; (6) collaborate; (7) communicate to other audiences; (8) expect the unexpected; (9) anticipate changing technologies; and (10) think about information technology abstractly.

Fundamental/foundational concepts are the enduring foundations of information technology and will continue to be expounded upon with the integration of new concepts as well as new information technologies (NRC, 1999). These concepts provide learners with an understanding of information technology as it changes over time, and demonstrates the potential and limits of the technologies (Dougherty et al., 2002b). The 10 key concepts that the NRC (1999) established are: (1) computers; (2) information systems; (3) networks; (4) digital representation of information; (5) information organization; (6) modeling and abstraction; (7) algorithmic thinking and programming; (8) universality; (9) limitations of information technology; and (10) societal impact of information and information technology.

Contemporary skills refer to a person's ability to utilize hardware or software resources in order to perform certain information processing tasks (NRC, 1999). Dougherty et al. (2002b) classified these skills as pertinent to providing practical experience that will build new competencies in the learner. The 10 essential skills, as discussed by the NRC (1999) are: (1) setting up a personal computer; (2) using basic operating system features; (3) using a word processor to create a text document; (4) using a graphics and/or artwork package to create illustrations, slides, or other image-based expressions of ideas; (5) connecting a computer to a network; (6) using the Internet to find information and resources; (7) using a computer to communicate with others; (8) using a spreadsheet to model simple processes or financial tables; (9) using a database system to set up and access useful information; and (10) using instructional materials to learn how to use new applications or features.

FITness is personal, graduated and dynamic (NRC, 1999). It is personal as information technology is applied to an individual's lifestyle – in both personal and professional activities. It is graduated in sophistication, as a person is not simply fluent or not-fluent in information technology, but can be a level in between. Finally, it is dynamic as it requires lifelong learning through changes in information technology.

1.2. FITness rationales

While it is apparent that all members of society should have a basic understanding of information technology, reasons for their education may differ. The NRC (1999) lists four different rationales that motivate individuals to seek an understanding of information technology: personal, workforce, educational, and societal.

Personal rationale is perhaps the most obvious and compelling reason for individuals to seek fluency in information technology. The personal benefits of using information technology include the ability to keep in contact with family and friends via e-mail, planning vacations or pursuing hobbies using the Internet, managing finances with spreadsheets, helping children with homework through word processing and keeping up with the latest news in politics, the environment, medicine or even information about their community (NRC, 1999). Information technology makes these tasks easier to accomplish and are therefore more enjoyable to users.

Workforce Rationale is necessary if society wants to reap the most benefits from information technology (NRC, 1999). "International competition from nations with strong education systems and millions of highly educated, skilled workers roils the markets – and the US workforce – every day" (Vockley, 2007, p. 2). The world is catching up in terms of innovation, economic competitiveness, and educational achievement.

Educational Rationale benefits students of all ages. According to the NRC (1999), students can develop their critical thinking abilities using information technology – it applies to anything from discerning credible information on the Internet to evaluating the validity of commercial advertisements.

Finally, Societal Rationale applies to policy debates and the advantages and disadvantages of information technology on society. These issues include privacy, such as credit card and bank information available online; copyright laws, as information can be disbursed to the public easily and illegally; and the right to free expression, as anything can be posted on the Internet (NRC, 1999).

1.3. FITness in high schools and universities

It would be most beneficial to begin fluency in information technology education when students are young. However, it was found by Becker (2001 cited in Barron, Martin, Mercier, Roberts, and McPhee (2004)) that opportunities for students to study technology is limited, as a national probability sample of US high schools reported that only 10% of computing classes involved computer science or programming and only 4% focused on multimedia or design. On the other hand, there has been more research on the introduction of FITness into high

schools as well as for young people in general, and the positive effects it has on students' learning and their college and career plans. For example, the Massacusetts Institute of Technology (MIT) Media Lab and the Boston Museum of Science established multiple learning centers for students from lower socioeconomic status (Resnick, 2002). The centers are known as Computer Clubhouses, where students are able to create their own art work, computer programs, multimedia presentations, web sites and much more. This in turn increases their self-efficacy and increases their job marketability (Resnick, 2002).

Barron's study (Barron, 2004) examined fluency-building experiences in a Silicon Valley High School. More-experienced students used a higher number of learning resources and were more likely to use tutorials, classes in the community, and books to learn more about technology. In addition, the students taking a greater number of programming classes demonstrated a larger interest in computing than those who did not (Barron et al., 2004).

There are a number of universities – in the United States and worldwide – that use different learning strategies in teaching information technology. Among these are Dartmouth College, Trinity University, and City University of New York – Queens College (Aiken, Kock, & Mandviwalla, 2000). Trinity University offers "Laboratory for Great Ideas in Computer Science," which focuses on covering a substantial number of information technology topics in a laboratory. The City University of New York – Queens College also offers a course in the acquisition and presentation of data and information, providing students a high level of Internet mastery.

Dougherty et al. (2002a) conducted case studies in a university setting in an attempt to identify a successful teaching method. Individuals in the case studies demonstrated that after taking specific courses, their perceptions of information technology improved. The comparison course also improved perceptions of information technology. This study found that participation in technology enhanced courses improved the learners perceptions of information technology in general and helped them realize the ability information technology gave them to solve tasks. The hands-on information technology use received the most positive student feedback. Students enjoyed working together, building skills and solving problems. This information should be used in the future for classes using information technology.

Cuckle, Clarke, and Jenkins (2000) conducted a study of student teachers' qualifications in information technology at the University of Leeds in the United Kingdom. They found that computer use and knowledge of information technology at the start of a Postgraduate Certificate of Education (PGCE) course was relatively low. Only 58% of students had considerable or constant computer use at a university, 43% used computers that same amount at home, and 38% used it in the workplace. The student teachers' qualifications in information technology were even lower. Only 13% had qualifications from school courses, 20% from national vocational or introductory courses at universities, 3% gained qualifications from the workplace and 1% had basic skills in computer literacy and information technology at home. However, after taking the PGCE course, many students who had relatively low levels of competence when they started the course improved their levels of skill, confidence and practice in using information technology for coursework, preparation, and teaching.

A college study, conducted at Southwestern University in Georgetown, Texas (McEuen, 2001), explored how FIT the students believed they were. Three hundred participants throughout the school, in different majors and years, filled out the survey, and 17 participated in personal interviews, further explaining the students' levels of fluency. It was found that 97% of the students owned a personal computer. However, female students' primary use of their computers was for communication (48% of the time), while male students' primary use was for entertainment (44% of the time). A major difference between genders was the level of fluency they believed they had, as males found themselves to be more fluent than females (76% compared to 59%). Students' skill levels were also evaluated. Eighty-nine to 99% of the students reported always using the computer for skills such as e-mail, browsing the Web, and typing papers. Approximately 52% sometimes use a computer to work with data. Fifty-eight percent never use the computer to create Web pages and 61.3% do not design or work with graphics.

Cole and Kelsey (2004) conducted a survey of post-registered nursing students in the United Kingdom. They found that 51.2% of respondents reported that they were unable to use the electronic library catalog and considered their ability to use electronic information services as less than adequate. In addition, only 71.7% of students had used the Internet and 65.9% used it to acquire information, while 45.1% reported their knowledge of the Internet was less than adequate. Only 49.1% had used e-mail. Approximately 10% of respondents reported their e-mail ability as less than adequate.

An assessment of college freshmen at orientation demonstrated their proficiency of skills using the Microsoft Office Suite (Tesch, Murphy, & Crable, 2004). Out of 20 basic tasks for Microsoft Word, at least 80% of students successfully completed 14 of them. Seven of the 29 tasks for Excel were completed by 80% of the students. Many were unable to delete selected cells, use formulas, such as absolute references, current date and time and relative cell references. At least 80% of students were successful at completing six of 15 PowerPoint tasks, including deleting and adding slides, running a slide show and editing contents. Finally, students were tested on their ability to use Microsoft XP and program management skills. Out of the 11 tasks, none were successfully completed by 80% or more of students. Ninety-eight percent missed the question pertaining to viewing contents of the Documents and Settings folder on the C: drive.

Wallace and Clariana (2005) conducted a study of 140 incoming freshman business majors to determine their computer knowledge and skills to see if an introductory computer fundamentals course is necessary at the college. Two tests were given, one for computer concepts and the other for the software program Excel. The computer concepts pretest showed a mean of 57.6 and the Excel pretest showed a mean of 59.5. After the course, the computer concepts posttest showed a mean of 78 and the Excel test showed a mean of 82.4. These scores demonstrate that incoming students do not have a basic knowledge of computer concepts and programs, despite professors' expectations.

A similar study was conducted by Hardy, Heeler, and Brooks (2006). At Northwest Missouri State University, students may test out of the introductory computer literacy course if they receive a score of 80% in mastery of various skills. However, after 164 students were assessed, it became clear that very few (three out of the 164) have the skills to test out of the course. The word processing assessment showed 20.7% of students having 80% or higher mastery, while a majority of students (51.2%) scored between 60% and 79% on their proficiency. The students' proficiency on spreadsheet skills was poor, as 69.5% showed less than 60% mastery. They demonstrated an even poorer proficiency at database skills as 81.1% had less than 60% mastery of skills. In both spreadsheet and database skills, only 1.2% of students had an 80% proficiency. There was a slight improvement in computer concepts, as 1.5% of students had 80% mastery; however, 83.5% had less than 60% mastery. Overall the assessment demonstrated that 73.8% of students had less than 60% computer literacy, 25% scored between 60 and 79% on literacy and 1.2% scored the required 80% or higher to test out of the course.

These studies indicate that while a large majority of students indicate that they own computers and have access to the Internet, their use is often limited to activities such as communicating and game playing. When assessed for their levels of FITness, the results are disappointing. Fortunately, interventions such as requiring specific course work or increasing the use of technology in instruction appear to

enhance both skills and self-efficacy. Therefore institutions of learning need to monitor the technology literacy levels of their students and design interventions to ensure that graduates have the knowledge and skills they will need to succeed in the workforce.

2. Methods

At a mid-sized research-one institution, in the fall of 2001, we surveyed incoming freshmen (Kaminski, Seel, & Cullen, 2003). All freshmen were required to attend a freshman seminar. We contacted the instructors and attended class, handing out the paper survey. Of 3898 students in the freshman class, we received 2102 correctly completed surveys. This method gave us a usable response rate of 54% of the entire freshmen class. In the spring of 2005 we implemented a modified survey, this time surveying graduating seniors. All seniors were required to attend a capstone course. This time, we surveyed a stratified-random sample of seminars ensuring that we included senior capstones from each of the eight academic colleges on campus. Again we visited the class and used a paper and pencil survey receiving 482 completed surveys for a response rate of 82%. It should be noted that this was not a within subjects or repeated measures design. In other words we took samples from the class in each of the two years noted, but those responding were not necessarily the same students, but where randomly selected from the overall class (freshmen in 2001 and seniors in 2005). Thus the design was a mix between a time series and pre-test post test design but it was **not** a repeated measures design since the same students were not measured in the two years (Gliner, Morgan, & Leech, 2009; Morgan, Leech, Gloeckner, & Barrett, 2007).

On the surveys we held a number of questions constant. This included the questions on perceived knowledge and skills in specific areas of technology fluency (Table 1). Note that the closer the average is to 1.0 the more proficient they felt, the closer to 4.0 the less they have used it/less proficient they felt.

3. Findings

Table 2 shows both groups mean responses from the seniors and the freshman as well as *t*-test and significant values. Seniors reported that they believed they were between very proficient and somewhat proficient in word processing (1.30), browser (1.32), and presentation software (1.81). They reported feeling somewhat proficient in spreadsheets (2.09) and between somewhat and marginally proficient in graphics (2.70). While desktop publishing (3.15) and databases (3.15) were both reported close to marginally proficient, web animation (3.36), web development (3.37), programming (3.63), digital video (3.69), and digital audio (3.75) were all between marginally proficient and never used.

The responses to perception of proficiency using technology from the freshman survey and the senior survey were compared using an independent *t*-test.

3.1. No significant difference

There was no significant difference in perceived ability for Word Processing, Spread Sheet, Graphics (Adobe, Photoshop, Illustrator), and Web Development (DreamWeaver). It is also not surprising that freshmen's perception was that they were very proficient in Word Processing and seniors' also perceived high proficiency in word processing. In addition the consistent perception of somewhat proficient in spread sheets is consistent with a commonly used software application. With graphics they were both just above marginally proficient. It is surprising that this did not increase between freshman and senior perceptions. With the easy access to computers and digital software, and

Table 1
Example Questions from Survey.

(26) Spreadsheets (e.g. QuattroPro, Excel)	(A) Very proficient	(B) Somewhat proficient	(C) Marginally proficient	(D) Never used
(27) Presentation (e.g. PowerPoint, Corel)	(A) Very proficient	(B) Somewhat proficient	(C) Marginally proficient	(D) Never used
(33) Graphics (e.g. Adobe Photoshop, Illustrator)	(A) Very proficient	(B) Somewhat proficient	(C) Marginally proficient	(D) Never used
(36) Digital video production (e.g. iMovie, Final Cut Pro, Avid Xpress)	(A) Very proficient	(B) Somewhat proficient	(C) Marginally proficient	(D) Never used
(37) Digital audio production (e.g. Sound Forge, Sound Edit)	(A) Very proficient	(B) Somewhat proficient	(C) Marginally proficient	(D) Never used

Table 2
Comparison of freshman and senior data.

Item	Mean freshman	Mean seniors	*t*	Sig. (2-tailed)	Mean difference	95% Confidence interval
Word processing	1.26	1.30	−1.430	.153	.035	
Spread sheets	2.07	2.09	−.467	.641	.018	
Presentation	2.34	1.81	13.989	.001**	−.532	.61:.46
Database	3.05	3.15	−2.572	.010*	.117	.03:.21
Browser	1.41	1.32	3.092	.002**	−.089	.15:.03
Web animation	3.23	3.36	−3.330	.001**	.136	.06:.22
Programming	3.45	3.63	4.736	.001**	.178	.10:.25
Graphics	2.74	2.70	−.702	−.483	.033	
Desktop	3.06	3.15	−2.004	.046*	.095	.00:.19
Publishing Web development	3.44	3.37	1.623	.105	−.073	
Digital video	3.36	3.69	−8.054	.001**	.320	.24:.40
Digital audio	3.20	3.75	−14.131	.001**	.547	.47:.62

Note: A negative *t* means a decrease; a positive *t* means an increase in self evaluated skills from freshman to senior. Confidence intervals are given for significant findings.
* Significance < .05.
** Significance < .01.

the heavy use of presentation software, it was believed their ability to create graphics would increase. It was also surprising that both the majority of freshman and seniors reported that they almost never use Web Development Software. Students are heavily using presentation software but are not learning to create Web pages for information presentation.

3.2. Significant decrease

It is important to note that for all items with a significant decrease, database (Access), web animation (Flash), programming (Java), desktop publishing (Publisher, Pagemaker), digital video (Final Cut Pro or iMovie), and digital audio (Sound Edit), that these means are greater than 3.0. This indicates that for every item that decreased, Freshmen did not feel proficient when they arrived and seniors reported feeling even less proficient after their time at the University. This change avoids the one sentence paragraph.

It is interesting that we use so many databases to access information, but the students are not learning how to manage information within a database. It follows that Web development skills are perceived to be low and so does web animation. The students are learning to use simple presentation software, but not to create more significant visual representations. The most surprising results are that both digital audio and digital video perceptions decreased significantly. There is an assumption that students are immersed in digital audio and video. Computers come with free software that allows creation and editing of digital audio and video. Yet for both of these, students reported not very proficient or had never used the software.

In regard to digital video, the interesting thing here is that the decrease in perceived proficiency is 1/4 point to almost 1/2 point – so it is a greater change in the negative direction that the prior points. For digital audio they started out a bit more confident than digital video (3.20 vs. 3.36 for freshman) and the change was greater in the negative direction (3.75 vs. 3.69 for seniors). Here they moved slightly more than 1/2 point down the scale.

One possible explanation is that the university did not offer an opportunity to work with these categories of software. Another is that students, as graduating seniors, were more aware of the fact that they did not have sufficient knowledge and skills in these categories.

3.3. Significant increase

There was a significant increase in presentation software (e.g., Power Point) and Browser (e.g. Explorer, Mozilla Fox Fire). It is not surprising that there was a significant increase in perceived ability in creating presentations with the mean decreasing by almost 1/2 point, and using a browser. The University's core curriculum includes courses that require the students to give oral presentations. Presentation software is commonly used to support their activities. Browsers are also commonly used to search for information including library resources, and to access the Learning Management System, student records, and registering for courses.

4. Discussion

The findings in our study parallel findings in Salaway, Caruso, Nelson, and Dede's (2007) Educause Center for Applied Research study of Undergraduate Students and Information Technology. They asked similar questions on student perception with a scale rating of 1 poor, 2 fair, 3 good, 4 very good, 5 excellent. Their respondents indicated they have the most confidence in their presentation software (such as PowerPoint) skills, with mean ratings close to "very good": means for seniors 3.88 and freshman 3.84. Reported skill levels for spreadsheets, online library resources, and computer maintenance were rated somewhat lower, between "good" and "very good." The mean for Spread Sheets for seniors was 3.61 and freshman was 3.29 also indicating a slight increase. Far fewer of their respondents reported use of software designed for creating graphics or video/audio. Those respondents indicate lower skill levels – slightly less than "good." The means for Graphics was seniors 2.86 and freshman 2.98 and the means for video/audio was seniors 2.74 and freshman 2.92. Note that they also found that in the areas of graphics and video and audio there was a decrease in perceived skill level from freshman to seniors.

Although the students in both these studies reported perceptions of proficiency, we believe our study indicates that we are not engaging our learners in advanced uses of technology for communication, sharing information, and problem solving. There is definitely a lack of experience in the use of digital technologies such as creating digital audio, digital video, Web pages, and graphics to communicate learning or share information.

Technology literacy skills can be incorporated across the curriculum through the use of collaboration and scaffolding. Students in Salaway et al.'s (2007) study made three recommendations: develop instructors' technology skill sets; train instructors on how and when to effectively integrate technology and pedagogy; increase instructor and administrator awareness about how their students differ in technology savvy and access to technology resources, and how to actor that into instruction. We recommend that faculty in lower level courses can begin to incorporate some of the basic or intellectual (NRC, 1999) skills such as Web development using Dream Weaver, library data base searches, simple use of graphics and digital audio and video for presentations. Faculty in upper level courses can then help the students hone their conceptual skills by incorporating the use of technology for critical thinking and problem solving. Referring to the NRC guidelines will give faculty a place to start.

Faculty can take two approaches to incorporate technology literacy for student learning. They can learn the technology skills themselves and demonstrate for the learners or they can allow the students to work collaboratively to incorporate technology into their assignments and faculty can become knowledgeable on how to assess their use of technology without actually knowing how to use the technology themselves.

5. Conclusion

The results of the survey were made publicly available on campus. This was used by departments and technology support staff as talking points when working with faculty on course design and development and the importance of not only using technology to facilitate learning, but to require the students to use technology in their assignments. In a follow-up interview with faculty regarding technology use in departments, one department chair indicated that he used the information from the survey to make changes in their curriculum development.

Since we initiated this project at our University, Educational Testing Services (ETS) has developed hands-on skills tests for students called ISkills. There are two tests, one to determine the skills of incoming students and an advanced test which can be used when students are seniors or have more experience. The University library has purchased 500 of these tests which we will randomly implement across colleges in the spring of 2008. Results from these tests will give us and the participants' information about their actual skills. We will be able to compare the performance with students at other institutions. Although we are not ready to move to a technology skills requirement for graduation as some institutions have (Missouri State University requires the ISkills test for all students, San Diego State University requires 70% proficiency on the ISkills to graduate), we will continue to use this information to inform our faculty about the importance of technology literacy and how well our students are doing compared to a standard and now compared to other institutions. "In a digital world, no organization can achieve results without incorporating technology into every aspect of its everyday practices. It is time for schools to maximize the impact of technology as well." (Vockley, 2007, p. 2)

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