ASEE's 123rd Annual • Conference & Exposition • New Orleans, LA • June 26-29, 2016

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Paper ID #14898

# Investigating First-Year Engineering Students' Educational Technology Use and Academic Achievement: Development and Validation of an Assessment Tool

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# Investigating First-Year Engineering Students' Educational Technology Use and Academic Achievement: Development and Validation of an Assessment Tool


## Abstract

Previous scholars have examined the use of educational technology as a strategy for improving student outcomes and skills. Generally, past studies of technology have focused on devices such as computers and cellphones or word processing and web-based software. Students have reported positive perceptions of educational technology as it relates to their learning, involvement and connectedness, to name a few. However, differences exist in undergraduate students' reported technological skill and use by major, class rank, gender, and race/ethnicity. Since technology is ever-changing and context-specific, this paper describes the development and validation of a particular assessment tool – one focused on the specific types of and ways that educational technology is used by first-year engineering students (FYES). More specifically, the assessment tool was used in an investigation of the relationship between first-year engineering students' perceived (a) knowledge, (b) usefulness, as well as (c) frequency and nature of use of educational technology and their academic achievement (i.e., grades). Differences were analyzed by race/ethnicity and gender. After distributing the assessment tool and collecting data from nearly 500 students at a single institution, results revealed there are significant racial/ethnic differences in FYES' perceived usefulness as well as frequency and nature of use of educational technology. There are also significant gender differences in FYES' perceived knowledge and usefulness of educational technology. Furthermore, FYES' background characteristics significantly predict their final course grades in the second of two introductory engineering courses. Future work will explore the aforementioned findings in detail. However, this paper offers implications for practice, research, and theory surrounding the assessment tool.


## Introduction

Increasing the number of Americans who graduate with a degree in science, technology, engineering and mathematics (STEM) is of compelling national interest as the world is becoming more technologically-dependent.[1] As society changes there is a continual need for new devices, tools, and services. Therefore, what is represented as "technology" constantly changes. The underlying meaning of technology is fairly stable, but the term is employed differently across context and application. In society, a variety of technologies are used to provide people with things like food, healthcare, shelter, transportation, and entertainment. In educational settings, computers and other information technologies help individuals learn, teach, and communicate.

Prior researchers have studied the use of educational technology as a way to improve student outcomes and skills. Previous studies of educational technology have shown that college students believe it provides increased control of classroom activities, improved learning, greater educational involvement, cognitive/personal development, convenience, and connectedness with others.[3-6] However, students also report a preference for only a moderate amount of educational technology use in the classroom, a desire for instructors to use more open educational resources and gaming tools, a lack of confidence in their core software skills, and less comfort with more specialized forms of educational technology.[2,5,7,8] There also are reported disparities in technological skill and use among various types of undergraduate students.[4,6,9-12]

Previously, scholars have employed a broad definition of technology to describe hardware such as cell phones and computers or software for word processing and web-based applications. Such definitions have been used to understand how collegians, instructors, and professionals interact with technology. In the present study, educational technology signified specific computer and information technology such as computer hardware (e.g., desktops, laptops), computer software (e.g., Microsoft Word/Excel, MATLAB, SolidWorks), electronic devices (e.g., cellphones, tablets, E-readers), and the Internet (e.g., websites, course management systems). So, unlike previous analyses, the present study focused on the specific types of and ways that educational technology is used by first-year students in engineering (FYES).

## Purpose

The purpose of this study was to develop and validate a particular assessment tool – one focused on the specific types of and ways that educational technology is used by first-year engineering students (FYES). More specifically, the assessment tool was used in an investigation of the relationship between FYES' perceived (a) knowledge, (b) usefulness, as well as (c) frequency and nature of use of educational technology and their academic achievement (i.e., grades). Differences were analyzed by race/ethnicity and gender. The label 'first-year engineering students (FYES)' refers to undergraduates of all class ranks that are enrolled in an introductory engineering course within a first-year engineering program.

## Literature Review

**Value of educational technology.** As previously mentioned, in prior studies, students have reported positive perceptions of educational technology as it relates to their learning, involvement and connectedness. For example, in an EDUCAUSE Center for Applied Research (ECAR) study of 10,000 U.S. students at 184 colleges/universities, over two-thirds of individuals believe technology "helps them achieve their academic outcomes," "prepares them for future educational plans" and "prepares them for the workforce." [2] Over half of all participants believe they are "more actively involved in courses that use technology" and that technology "helps them feel connected" to other students, their teachers, and their institutions. Furthermore, students indicate the most important devices to their academic success are laptops, followed by printers, thumb drives, and desktop computers.

Past researchers have also focused on students' technology use and learning. In a study of over 3,800 first-year undergraduates at 5 two-year and 18 four-year colleges/universities, researchers determined that computer use has positive effects on student development outcomes.[3] Particularly, computer use has significant positive effects on two-year students' perceived reading comprehension and overall cognitive development. Additionally, the extent to which two-year students use computers for classroom assignments has significant positive effects on overall cognitive development. The extent to which first-year community college students' courses require them to learn how to use computers or word processors has a significant positive influence on critical thinking too. Student engagement in computer word processing has significant positive effects on first-year reading comprehension, with African Americans experiencing significantly greater benefits than other students. Finally, freshmen four-year students with the highest levels of overall precollege cognitive development have significant, positive first-year cognitive gains from email use.

**Student differences related to technology.** Undergraduates experience college differently depending on their major, class rank, gender, and race/ethnicity. So, it is useful to discuss such discrepancies before describing the targeted variables and population of this study. Students' chosen major impacts their experience through college, as individuals in fields such as science and engineering complete specialized coursework and interact with tools like educational technology in a distinct way.[11,12] Class rank also matters. Freshmen use computer and information technology less frequently and interact with less specialized forms of educational technology when compared to seniors.[4] Furthermore, scholars have revealed that women and historically underrepresented racial/ethnic minorities (URMs) – Blacks, Hispanics, and Native Americans – face unique barriers (e.g., academic, social) to their success and ultimate degree completion in college, especially in science and engineering disciplines.[13-20]

When comparing students' use and engagement with educational technology, differences also exist across gender. Researchers have shown that females report lower confidence, later adoption, less frequent use of educational technology such as multimedia, lower use for academic purposes, and interaction with less advanced forms of educational technology than males.[4,6,10, 21,22] Similarly, differences occur across race/ethnicity. Of all racial/ethnic groups, American Indian/Alaska Native students are most likely to search the Internet for research or homework while White students use computers for academic work less often than non-White students.[6,9] Despite existing research concerning the value of educational technology and student differences related to technology, research on current tools is needed. The present study will address this need by focusing on the specific types of and ways that educational technology is used by FYES.

## Theoretical Framework

According to Rogers' Diffusion of Innovation Theory, technology adoption occurs through a five-step innovation-decision process.[23] The steps consists of, (a) knowledge, (b) persuasion, (c) decision, (d) implementation, and (e) confirmation. The first step, knowledge, takes place when an individual becomes aware of an innovation and begins to understand how it works. Step two, persuasion, occurs when someone develops a positive or negative perception of a technology. The third step, decision, happens when an individual chooses to adopt or reject an innovation. It is important to note that an individual can first adopt then later reject (i.e., discontinuance) or first reject then later adopt. Step four, implementation, occurs after someone adopts then begins to use a technology. The fifth step, confirmation, takes place when an individual seeks to reinforce their decision about an innovation (e.g., by receiving supportive messages). Based on Rogers' theory, it is important to understand why, how, and if individuals adopt technology.[23] The innovation-decision process helps to explain the choices and actions that are made by people after being exposed to a technology. See Figure 1 for a visual representation of the process.

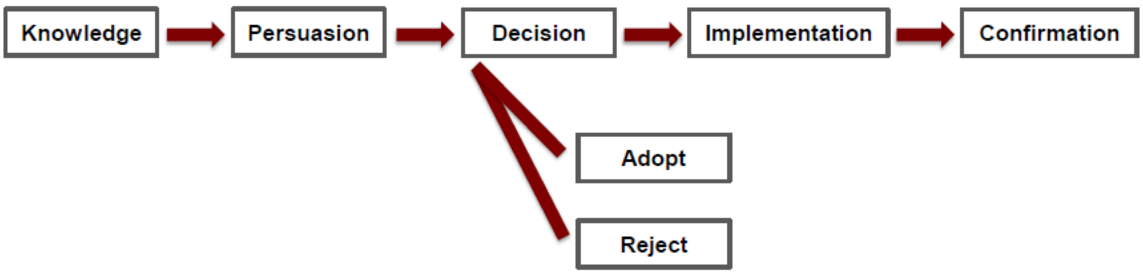


Figure 1: Re-creation of Roger's Innovation-Decision Process [23]

## Method

*Research Population and Sample*

The research population for the present study is first-year undergraduates in engineering. This specific population represented several qualities: (a) unique transition experiences of first-year students, (b) high student attrition rates in STEM, and (c) differences across STEM majors.[11,12,16, 24, 25] While transitioning to college, first-year students face unique academic, social, and financial experiences.[24-25] In addition, collegians tend to leave STEM during their freshman or sophomore year, with greater rates among URMs.[16] Furthermore, variations (e.g., coursework, technology use) exist across STEM disciplines.[11,12] By targeting this population, efforts can be made to increase engineering student satisfaction and success during the first year of college. The U.S.' workforce and global competitiveness can benefit from an increase in the number of American STEM graduates.

The research sample consisted of approximately 1,600 FYES enrolled at a large, public, research, 4-year, predominantly White institution (PWI) in the Midwest. This sample contained a large number of eligible participants. In terms of gender, this sample of eligible participants was nearly representative of national averages for full-time, first-year female engineering students. However, this sample contained a less than nationally representative proportion of full-time, first-year URM engineering students. Although the first-year engineering program at the institution includes four tracks (i.e., standard, scholars, honors and transfer courses), only FYES within the standard track participated in the study. Potential participants were identified through their enrollment in the selected institutions' fundamental/introductory engineering courses. Each of the 16-week courses was designed to provide students with knowledge of fundamental engineering topics such as technical communication, problem solving, data collection/analysis, technical graphics, and the design process. The two-course sequence was a pre-requisite before students could take introductory courses for most engineering disciplines at the institution.

Students under the age of 18 were excluded from the study for two reasons. First, it was difficult to gain parental consent from these individuals. This was especially difficult for out-of-state students and parents. Second, results from prior research suggest that the experiences of students under the age of 18 may be qualitatively different from those who are 18 and over, especially when interacting with same-age peers.[26] After excluding roughly 70 minors (i.e., less than 7% of willing participants), only students who were at least 18 years old at the beginning of the fall semester were included in this study.

It can be noted that 487 FYES, who enrolled in the standard track at the institution during the fall of 2013 and spring of 2014, agreed to participate in the study and were at least 18 years old. This yielded a response rate of roughly 30%. Of the 487 students in the aggregate sample, about 20% self-reported as being a female and nearly 7% identified as a URM (i.e., African Americans, Hispanics, and Native Americans). Roughly two-thirds (66.1%) were ranked as a freshman and almost all (89.3%) were an engineering pre-major. So, a slightly above nationally representative group of female full-time, first-year engineering students agreed to participate in the study while URMs were represented at about half of their national average. Additional demographic information for this sample is summarized below in Table 1, with values totaling 100 ± 0.1 %.

Table 1

*Description of samples*

| Variables | % | % | % | % | % |
|---|---|---|---|---|---|
| ***Academic*** | Aggregate (N=487) | Non-White (N=109) | White (N=345) | Female (N=98) | Male (N=389) |
| **Admission classification** | | | | | |
| New freshman | 78.6 | 74.3 | 78.8 | 79.6 | 78.4 |
| New advanced undergraduate 1 & 2* | 4.1 | 5.5 | 3.5 | 5.1 | 3.9 |
| New advanced undergraduate 3 & 4** | 4.1 | 5.5 | 3.8 | 4.1 | 4.1 |
| Continuing undergraduate | 11.5 | 13.8 | 11.9 | 11.2 | 11.6 |
| Old returning undergraduate | 1.6 | 0.9 | 2.0 | 0 | 2.1 |
| **Class Rank** | | | | | |
| Freshman | 66.1 | 66.1 | 66.1 | 62.2 | 67.1 |
| Sophomore | 22.6 | 21.1 | 22.6 | 28.6 | 21.1 |
| Junior | 6.6 | 10.1 | 5.8 | 7.1 | 6.4 |
| Senior | 4.7 | 2.8 | 5.5 | 2.0 | 5.4 |
| **Pre-Major** | | | | | |
| Has not declared a pre-major | 6.4 | 4.6 | 7.5 | 6.1 | 6.4 |
| Non-engineering pre-major | 4.3 | 5.5 | 4.4 | 4.0 | 4.3 |
| Engineering pre-major | 89.3 | 89.9 | 88.1 | 89.8 | 89.2 |
| ***Demographic*** | | | | | |
| **Sex of student** | | | | | |
| Male | 79.9 | 72.5 | 82.0 | 0.0 | 100.0 |
| Female | 20.1 | 27.5 | 18.0 | 100.0 | 0.0 |

Continued

Table 1 continued

| | | | | | |
|---|---|---|---|---|---|
| **Race/Ethnicity** | | | | | |
| African American/Black | 2.7 | 11.9 | 0.0 | 4.1 | 2.3 |
| American Indian/Alaska Native | 0.6 | 2.8 | 0.0 | 1.0 | 0.5 |
| Asian/Pacific Islander | 6.6 | 29.4 | 0.0 | 10.2 | 5.7 |
| Caucasian/White | 70.8 | 0.0 | 100.0 | 63.3 | 72.8 |
| Hispanic | 3.3 | 14.7 | 0.0 | 3.1 | 3.3 |
| International Student | 9.2 | 41.3 | 0.0 | 12.2 | 8.5 |
| Missing | 6.8 | 0.0 | 0.0 | 6.1 | 6.9 |
| **Age of student** | | | | | |
| 18-19 | 85.0 | 78.9 | 86.1 | 90.8 | 83.5 |
| 20-23 | 10.3 | 14.7 | 9.6 | 8.2 | 10.8 |
| 24-29 | 3.5 | 4.6 | 3.2 | 0.0 | 4.4 |
| 30-39 | 1.0 | 0.9 | 1.2 | 0.0 | 1.3 |
| 40-55 | 0.2 | 0.9 | 0.0 | 1.0 | 0.0 |
| **First-generation status** | | | | | |
| Not a first-generation student | 85.2 | 81.7 | 87.2 | 87.8 | 84.6 |
| First-generation student | 14.8 | 18.3 | 12.8 | 12.2 | 15.4 |
| **Pell Grant** | | | | | |
| Not a Pell Grant recipient | 96.5 | 98.2 | 95.7 | 98.0 | 96.1 |
| Pell Grant recipient | 3.5 | 1.8 | 4.3 | 2.0 | 3.9 |

*Note*: * Transfer students at academic level 1 or 2

** Transfer students at academic level 3 or 4

*Data Collection*

A quantitative approach was employed to meet the objectives of the present study. However, a pilot-version of a subsequent explanatory qualitative component was used to add depth and discuss the numerical results. In this paper, only the quantitative portion will be described.

Quantitative data was collected during two terms, autumn semester 2013 (AU13) and spring semester 2014 (SP14). A slightly different version of the 24-item questionnaire was administered each semester. The exact differences in survey questions will be addressed later in this paper. The survey was organized into three sections, perceived: (a) knowledge of educational technology, (b) usefulness of educational technology, as well as (c) frequency and nature of use of educational technology. The first two sections contained 10 items and the last section had 4 items. Specific questionnaire items were distributed using weekly journals (referred to as "quizzes") on the institution's course management system. The journals were an existing assignment within the two introductory engineering courses. Figure 2, below, shows the period at which Rogers' process and related survey items, appeared during an academic term.

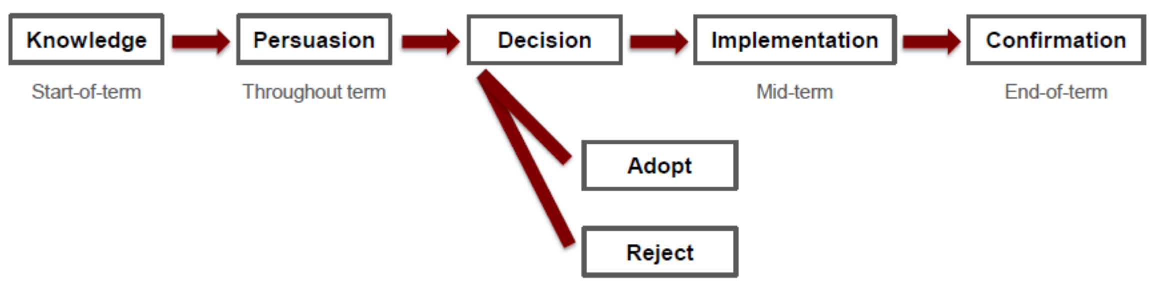


Figure 2: Use of Survey Instrument based on Roger's Innovation-Decision Process [23]

Students accessed the electronic survey items through a link on their course's management page and offered consent if they were willing to participate in the investigation. Permission was granted from the institution's Institutional Review Board (IRB) concerning the questionnaire. Students' self-reported demographic information (e.g., race/ethnicity, class rank, major), which is collected by the University, was used in conjunction with the survey responses. Student identity data and survey responses were placed on a secure University server. Students' ID number linked them to their survey data. Their personally identifiable information was located in a separate file from their survey responses. Data was stored electronically on a secure network drive within the university's servers and a protected course management site. Only the investigators and co-investigators had access to the personally identifiable data.

*Instrumentation*

The survey consisted of original questions and some modified items from the 2012 The National Survey of Student Engagement (NSSE) and 2011/2012 ECAR Study of Undergraduate Students and Technology Questionnaire. As described below, some preexisting survey items contained different scales. Permission was granted from both ECAR and NSSE. The NSSE survey collected self-report data on the extent to which students are engaged in educationally purposeful activities while focusing on desirable learning and personal development outcomes.[27] On the other hand, the ECAR survey elicited information about student experiences with and attitudes toward educational technology.[2,7] See Table 2 below for a blueprint of the survey questionnaire.

Table 2
*Blueprint of survey questionnaire*

| Section | Source of Items | N of Items |
|---|---|---|
| **Section One** | | |
| Perceived Knowledge | Original questions | 10 |
| **Section Two** | | |
| Perceived Usefulness | *ECAR Study of Undergraduate Students and Technology, 2012*. Retrieved from https://library.educause.edu/~/media/files/library/2012/9/esi1208.pdf | 5 |
| Perceived Usefulness | *ECAR Study of Undergraduate Students and Technology, 2011*. Retrieved from https://library.educause.edu/~/media/files/library/2011/10/esi11d-pdf.pdf | 5 |
| **Section Three** | | |
| Perceived Frequency of Use | *The National Survey of Student Engagement (NSSE), 2012*. Retrieved from http://nsse.indiana.edu/html/survey_instruments.cfm?siFlag=yes&sy=2012 | 2 |
| Perceived Frequency of Use | Original questions | 2 |

**Section One.** The first section of the questionnaire explored students' perceived knowledge of computer and information technology. Five original questions were included twice for a total of 10 items. Questions were created to prompt FYES about their task-specific knowledge of technological tools used in the course sequence such as word processors, spreadsheets, MATLAB, CAD (computer-aided design) programs, and microcontroller software. For instance, participants were asked "In terms of using a word processor (like MS Word) to perform tasks such as creating/formatting written documents, how would you rate your current knowledge?" Students used a 6-point Likert scale from 0 (*no prior knowledge*) to 5 (*very high*) to rate their replies. The five questions were given to students at the beginning and end of the semester for a total of 10 items about perceived knowledge.

**Section Two.** The second section of the questionnaire investigated students' perceived usefulness of computer and information technology. A total of 10 questions were developed. Five questions from the 2012 ECAR Study of Undergraduate Students and Technology were adapted to prompt FYES about the importance of certain technological devices to their academic success. For example, participants were asked "Regardless of whether or not you own one, please rate how important desktop computers/laptops are to your academic success." Students used a 6-point scale from 0 (*not at all important*) to 5 (*very high*) to rate their responses. Five questions were also adapted from the 2011 ECAR Study of Undergraduate Students and Technology to assess FYES' level of agreement with various statements about technology. For instance, participants were asked "To what extent do you agree with the statement 'Technology makes it easier to get help when I need it'?" Students used a 5-point scale from 0 (*strongly disagree*) to 4 (*strongly agree*) to rate their responses. The aforementioned items were given to students throughout the semester for a total of 10 items about perceived usefulness.

**Section Three.** The last section of the questionnaire assessed students' perceived frequency and nature of use of computer and information technology. A total of 4 questions were established. Two questions from the 2012 National Survey of Student Engagement (NSSE) were adapted to prompt FYES about the frequency of their use of computer and information technology for academic purposes. For instance, midway through the semester, participants were asked "During the current semester, about how often have you used email to communicate with an instructor or TA for this course?" Students used a 4-point scale from 0 (*never*) to 3 (*very often*) to rate their use. In addition, two original questions were generated to learn about students' ownership of software and use of optional educational technologies. For example, midway through the term, participants were asked "During the current semester, about how often have you used the optional storage mediums (such as Dropbox, Box and Google Drive) that are described in the Student Resources Guide to complete course assignments?" Students used the same 4-point scale that was previously mentioned to rate their use.

*Validity and Reliability*

Validity is "an integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences and actions based on test scores or other modes of assessment." [28] For the purposes of this study, a literature review, group of first-year engineering instructors, and panel of experts were used to establish face and content validity. This process was necessary to ensure that the assessment tool covered concepts related to the subject, with the appropriate coverage of the topic.[29] The dissertation examination committee for this study served as the primary panel of experts. In addition, the first-year engineering program director and two experienced graduate teaching associates at the selected institution also reviewed and approved of the survey questions.

As previously stated, this study relied on student self-reports. This data is generally considered valid if the requested information is known by the participants, if the questions are phrased clearly, and if the students believe the question is worthy of a response.[30] A panel of experts was used to make sure the information would be known to participants and the questions were phrased clearly. Students deemed questions worthy of a response since they were embedded within the curriculum of their fundamental/introductory engineering courses.

Since some items were borrowed or adapted from the NSSE and ECAR questionnaires it was important to discuss the validity and reliability of each survey tool. To establish content validity, the NSSE relies on a panel of experts and uses student self-report data.[31] In terms of reliability, NSSE has a reported value of 0.70 or higher for deep learning which includes higher-order, integrative, and reflective learning items.[32] Reliability values close to or above 0.70 are generally considered acceptable in statistical analysis.[33] In terms of response process validity, NSSE used cognitive interviews and focus groups to determine that the survey was valid for students of different races/ethnicities.[34] ECAR has not published information on the validity or reliability of its questionnaires.

Since the present study relied on a newly constructed assessment tool, a panel of experts was used to evaluate its validity. When evaluating the adequacy of the overall survey for each semester, one dissertation committee member and full professor of higher education, stated "overall, the survey appears well-constructed for the purposes of the study; adequate for assessing students' experiences with technology and perceived outcomes." Another committee member and assistant professor of science education, indicated "the survey covers important aspects of student views about technology." When describing the survey's ability to answer the specified research questions, the first committee member explained "on face value, the survey appears adequate for providing information to answer the study's research questions. Most items are well constructed, using expected response options, score ranges, and quantifiable responses." Furthermore, the second committee member said "assuming that the research methods and data analysis approaches are properly designed and implemented, the survey instrument can be useful for answering the research questions."

In addition to evaluating validity, a reliability analysis was conducted via SPSS, a statistical package for the social sciences, for the AU13 ($\alpha = 0.49$) and SP14 ($\alpha = 0.77$) questionnaires. The SP14 survey items were more reliable than those used during AU13. When referring below to Table 3, it should be noted that the items which measured students' perceived usefulness of educational technology differed between the AU13 and SP14 questionnaires. This variation can partially explain the change in reliability between the two questionnaires.

Table 3
*Reliability statistics for surveys*

| | Cronbach's Alpha | N of Items |
|---|---|---|
| AU 13 Survey | 0.49 | 24 |
| SP 14 Survey | 0.77 | 24 |

*Perceived Knowledge of Technology*

The present researcher hypothesized that some of the original items concerning students' perceived knowledge of educational technology formed a coherent subset or factor. After conducting a principal component factor analysis on the AU13 data, the present researcher determined that three of the five items loaded onto one factor. This accounted for 64% of the variance among items collected at each point in time. A subsequent reliability analysis produced a moderately acceptable value for items collected in the beginning of the term ($\alpha = 0.68$) and an adequate number for those gathered at the end ($\alpha = 0.70$). Ultimately, a variable called "Perceived Knowledge 3 (AU13): MATLAB, CAD, MCC" was created by computing the difference between the two aforementioned factors. Within this variable name, CAD stands for computer-aided design programs and MCC represents microcontroller software.

Similarly, a factor analysis was also conducted on the SP14 data, which was collected at the end of the term. The present researcher confirmed that the same three items concerning students' perceived knowledge of educational technology loaded onto one factor. This accounted for 63% of the variance among items. A succeeding reliability analysis produced an acceptable value ($\alpha = 0.70$). Finally, a variable called "Perceived Knowledge 3 (SP14): MATLAB, CAD, MCC" was generated by computing the difference between the SP14 factor and the one representing data from the end of AU13.

*Perceived Usefulness of Technology*

The present researcher also hypothesized that some of the original items concerning students' perceived usefulness of educational technology formed a factor. After conducting a factor analysis on the AU13 data, which was collected once during the term, the present researcher determined that four of the ten items loaded onto one factor. This accounted for 62% of the variance among items. A subsequent reliability analysis produced an acceptable value ($\alpha = 0.79$). Ultimately, a variable called "Perceived Usefulness 2 (AU13): Improves Work, Essential for College & Worthwhile" was created from the factor analysis.

Likewise, a factor analysis was also conducted on the SP14 data, which was collected once during the term. The present researcher confirmed that the same four items concerning students' perceived usefulness of educational technology loaded onto one factor. This accounted for 60% of the variance among items. A follow-up reliability analysis produced an acceptable value ($\alpha = 0.78$). So, a variable called "Perceived Usefulness 2 (SP14): Improves Work, Essential for

College & Worthwhile" was generated from the factor analysis. Table 4 below contains reliability statistics for all composite variables.

Table 4
*Reliability statistics for composite variables*

| | Cronbach's Alpha | N of Items |
|---|---|---|
| Perceived Knowledge 3 (AU13): MATLAB, CAD, MCC | 0.68 / 0.70 | 3 |
| Perceived Knowledge 3 (SP14): MATLAB, CAD, MCC | 0.70 | 3 |
| Perceived Usefulness 2 (AU13): Improves Work, Essential for College & Worthwhile | 0.79 | 4 |
| Perceived Usefulness 2 (SP14): Improves Work, Essential for College & Worthwhile | 0.78 | 4 |

**Delimitations**

As with all research, the present study has several delimitations. First, when focusing on the study's sample, all solicited participants were students from the same large, public, research, 4-year, predominantly White institution (PWI) in the Midwest. Furthermore, all participants were enrolled in the same introductory engineering courses. As a result, it is possible that students from this single institution and set of courses may differ in some important way from students at other colleges and universities. Therefore, results from this study may be unique to this institution.

Second, this study focused exclusively on engineering majors. STEM disciplines vary in several distinct ways. Students majoring in STEM fields take different coursework, outside of fundamental classes in math and science. As a result, students gain exposure to specialized curriculum and enroll in unique courses based on their class rank and specific major. Students also interact with discipline-specific educational equipment and technological tools. Consequently, discrepancies in students' use and knowledge of such equipment/tools arise across STEM fields. For instance, in prior studies, engineering students reported having higher use and skill than physical science majors with spreadsheet, computer programming, and discipline-specific software – such as Mathematica, AutoCAD, and STELLA.[11] In order to avoid conflation of majors, this study focused specifically on FYES.
Lastly, the chosen instrument for this study may limit the accuracy of the results. This analysis relied on a questionnaire which collects student self-reported data about technology. Self-reports are widely used in educational research despite a few challenges to their internal validity. As previously highlighted, they are generally considered valid if the information requested is known by the participants, if the questions are phrased clearly, and if the students deem the question worthy of a response.[30]

Despite the aforementioned delimitations, findings from this study add important insights to the extant literature on educational technology and first-year engineering students (FYES). Results provide insight into FYES' perceived knowledge, usefulness, as well as frequency and nature of use of technology.

## Discussion and Conclusion

This paper described the development and validation of a particular assessment tool. Unlike previous analyses, the present study and assessment tool focused on the specific types of and ways that educational technology is used by first-year students in engineering (FYES). More specifically, this assessment tool was used to investigate the relationship between first-year engineering students' perceived (a) knowledge, (b) usefulness, as well as (c) frequency and nature of use of educational technology and their academic achievement (i.e., grades). Differences were analyzed by race/ethnicity and gender. Despite existing research concerning the value of educational technology and student differences related to technology, research on current tools is continually needed.

A slightly different version of the assessment tool, a 24-item questionnaire, was administered during two terms, autumn semester 2013 (AU13) and spring semester 2014 (SP14). [35] Data was collected at a large, public, research, 4-year, predominantly White institution (PWI) in the Midwest. For the purposes of this study, a literature review, group of first-year engineering instructors, and panel of experts were used to establish face and content validity. In addition to evaluating validity, a reliability analysis was conducted for the AU13 and SP14 questionnaires. The SP14 survey items produced an acceptable value for reliability that was much greater than during AU13.

After distributing the assessment tool and collecting data from nearly 500 students, results revealed there are significant racial/ethnic differences in FYES' perceived usefulness as well as frequency and nature of use of educational technology. [35] There are also significant gender differences in FYES' perceived knowledge and usefulness of educational technology. Furthermore, FYES' background characteristics significantly predict their final course grades in the second of two introductory engineering courses. Future work will explore the aforementioned findings in detail.

Current undergraduates are often classified as being "digital natives." Nonetheless, findings from the present study indicate students' perceived knowledge, usefulness, as well as frequency and nature of use of technology varies by race/ethnicity and, or gender. Engineering educators should take such variations into consideration when seeking to create a positive learning environment for all students. Ultimately, the assessment tool that was developed and validated for the present study can be used by other researchers, instructors and administrators in engineering education.

Researchers can use the assessment tool to replicate the existing investigation or conduct a new analysis of FYES and educational technology. Present theory related to educational technology makes little mention of any student differences along race/ethnicity or gender. So, future researchers can continue to explore such variations by focusing on more diverse populations. Scholars can also conduct studies with FYES from other four-year institutions. Researchers can then compare different institutional types (e.g., public vs. private, Midwestern vs. Southeastern, large vs. small). Scholars can even modify the assessment tool for future work with students from other class ranks and STEM disciplines.

Instructors can use the assessment tool to better understand their students and inform their teaching. Faculty and staff teaching first-year engineering courses can use the assessment tool to gather information about their students' perceptions of educational technology. Then, they can redesign or enhance curriculum to suit the needs of an increasingly diverse student population. Faculty and staff can also use the assessment tool to comprehend the process by which their students adopt and use specific forms of educational technology.

Administrators can use the assessment tool to make decisions about technology purchases and course structures. They can use the assessment tool to provide current students with access to helpful forms of educational technology. Administrators can also use the assessment tool to determine what level of technological knowledge is expected of incoming freshman when making admission decisions. Lastly, administrators can use the assessment tool to develop criteria for rewarding and recognizing first-year engineering instructors who use evidence-based practices when integrating educational technology in to their courses.

## Acknowledgments

This research study was part of a doctoral dissertation titled, "An Investigation into the Relationship between Technology and Academic Achievement among First-Year Engineering Students." [35] The doctoral committee, consisted of co-advisors Dr. Paul Post and Dr. Terrell L. Strayhorn along with members Dr. Lin Ding and Dr. Robert Gustafson, who each provided invaluable feedback concerning the overall project.

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