Table of Contents

Volume XXXIX, Number 2, Fall 2013

Perceptions of New Doctoral Graduates on the Future of the Profession

By John Ritz and Gene Martin

Abstract

Advancement of a profession relies heavily on the participation of its members. Leadership roles must be filled at many levels. To effectively prepare future leaders, efforts must be undertaken to educate and mentor them both about their professions and how to lead within them. The authors sought to identify the perceptions of those who recently earned a doctoral degree with focus on technology and engineering education. In the past, this group developed and assumed major roles in leading their education professions. This study reports on new doctoral graduates' perceptions related to the focus of content taught in formalized K-12 technology and engineering education programs, methods used to prepare future technology and engineering teachers, characteristics of their planned professional involvement, and future forecasting for their school subject.

Keywords: New Ph.D. Perceptions, Profession, Technology and Engineering Education

Introduction

Public perceptions and economic circumstances often create disadvantages for the continued offering of K-12 school subjects that are classified as elective courses. In many cases, these elective courses are being eliminated from the school curriculum. This is no more evident than in the data revealed on the school subjects of technology and engineering education.

The number of teachers who teach in technology and engineering education programs has declined from 37,968 in 1995 to 28,310 in 2009, a loss of 9,658 teachers (35.4% decline) in just 14 years (Moye, 2009). The number of university programs that prepare these teachers also has declined from almost 300 in the 1970s to 27 (91% decline) identified in 2008 (Moye, 2009). These factors, plus the societal impacts associated with 9-11, the economic downturn of 2008, and the changing attitudes of the perceived value of belonging and participating in the sponsored activities of organizations, have caused a decline in the memberships of professional organizations (Martin, 2007). With fewer teachers entering the profession and fewer teachers joining professional organizations, how can the school subjects of technology and engineering education and their related professional education organizations keep the profession vibrant and provide the potential for change to meet the needs of their members and the students they serve?

The researchers of this study have been active participants in these school subjects for several decades and the professional organizations that are directly associated with them. They have provided guidance and teacher professional development to support these school subjects throughout their careers. They are very much aware that several universities, albeit a declining number, continue to prepare new professors who will train future teachers for these school subjects. They believe that the new technology and engineering teacher educators graduating from these doctoral programs have the challenge of continuing to prepare teachers for these school subjects to serve future generations of learners. Together, the researchers planned this study to determine the perceptions of new doctoral graduates on a number of issues related to technology and engineering education.

Consequently, this study was conducted for the purpose of determining directions that new graduates might pursue with their subject area's content, methods of future teacher preparation, planned professional involvement, and future forecasting of their school subject. The researchers' goal was to capture new graduates' perspectives about their profession in order to project what might be the future "health" of the profession by the year 2025. The anticipated beneficiaries of this study are individuals who closely identify themselves with mapping a course of action for the profession over the next 12 years. Professionals may use information reported in this study to initiate substantive discussions or even extend existing discussions on the future of the profession and the characteristics of individuals who will lead it.

Review of Literature

Organizations are formed by groups of people who bond together for a common purpose. K-12 schools are organizations, as are universities. Professional associations are organizations. To remain viable, organizations must adapt to changing environments (Senge, 1990). Adaptability is an important characteristic for the survival of any learning organization. Those who practice teaching, either in K-12 or at the university, have had to adapt their programs in order for their programs to remain viable. The associations that support teachers of technology and engineering also require continual change to better support their members.

Historically, professional associations provided a source of professional definition, a forum to increase public awareness, and a role in setting guidelines in preparing a person with appropriate credentials to practice that profession. The associations (a) provided professional development for their members, (b) set standards for educational practice, (c) organized and hosted forums on issues important to the members, and (d) attempted to unify political action campaigns to better position the profession (Phillips & Leahy, 2012). The major associations that represent the profession and technology and engineering education, including their state affiliates, practice many of the cited functions.

However, just as the number of technology and engineering teachers and their teacher preparation programs has been declining since the 1980s, similar reductions in professional memberships across various fields and disciplines have followed the same downward trend (Alotaibi, 2007; Bauman, 2008; Putnam, 2000; Yeager & Kline, 1983). These declines have caused professional organizations to cut services to members, just to survive economically (Martin, 2007). No longer can professional associations meet all the needs of their members. Consequently, this lack of help can cause further declines in memberships as people migrate to other associations they believe can provide the services to meet their individual needs.

Individuals join professional organizations because of the alignment of values they see between themselves, their profession, and the professional organization. The organizations they join often promote similar codes of ethics for professional conduct, work to preserve the subject's public image, and attempt to provide services to keep the professional current with the latest developments occurring within their field (Meltzer, 1996). As a result, people who join professional organizations care about their work within the profession (Rouch, 1999).

People who are perceived as leaders often lead professions and professional organizations. Some are hired as staff and others work as volunteers. Organization boards search for the best professionals to work in these positions to guide their associations in order to provide the best services and voice for their members. As their membership grows and develops professionally, it is most likely that they will improve the overall stature of their professions.

To become a professional leader usually takes years of professional development. A person must not only understand the knowledge base upon which the profession was established, but that person also must be willing to work for the betterment of the profession and its members. A leader must know how to work with others and direct them, get the tasks of the association accomplished, and plan for the future needs of the profession and its members. One function of leadership is thinking about the future (Gilberti, 1999).

When the technology and engineering teaching profession, particularly the Council on Technology and Engineering Teacher Educators (CTETE), began to vision its future, its members understood that new members would be needed to take over the leadership roles of the profession. Observations show that many talented leaders are good performers at their current jobs, leaders in their professions, and possible leaders of other organizations. Some leaders move on to other careers, causing voids in the leadership chain. High-performing members are not always there when associations need them to step into leadership roles as they move on to other career paths. These same observations show us that good leaders also retire, causing voids both at the workplace and in organizational leadership.

Colleges and universities have worked to develop models for the improved preparation of graduates who seek to become faculty members. In some fields, doctoral students take classes and work on research projects with faculty. These research projects sometime model what they will need to do in future faculty member positions. Many of these doctoral students prepare to become faculty, but they do not understand the teaching and service roles required in university positions. This creates problems for them when they transition into becoming teaching faculty members. In 1993, the Council of Graduate Schools and the Association of American Colleges and Universities designed a model labeled as "Preparing Future Faculty"; this program included three core components: "gaining teaching experience; learning about the academic triad of research, teaching, and service; and mentoring" (Richlin & Essington, 2004, p. 149). Its aim was to lessen the transition problems experienced by new doctoral graduates when they were hired to fill university faculty positions.

Most who seek to become professors of technology and engineering education have gained previous teaching experience and learned the best practices of teaching through degree work and on-the-job training. Many have student taught and operated their own classrooms/ laboratories. These doctoral students could learn the research and service branches of the university triad by working closely with faculty and research mentors. However, reports indicate that not all new faculty are mentored well to become academic citizens (Gaff, 2002) or learn the other important qualifications needed for a faculty position.

Through the leadership of William Havice of Clemson University and Roger Hill of The University of Georgia, the Council on Technology and Engineering Teacher Education (CTETE) initiated the Twenty-first Century Leadership Academy (CLA) Program. Beginning in 2006, this program was developed "to facilitate a sense of community and provide activities and resources to support scholarly and professional development opportunities for groups of early career technology education faculty" (Havice & Hill, 2012, para. 1). One of the goals of the program was to "grow our own leaders." The success of this program led it to become a part of the leadership program in the International Technology and Engineering Educators Association's (ITEEA) strategic plan in 2010. "One of the purposes of this program is to provide initial experiences to potential leaders so that they can evolve to become the next generation of professional leaders" (Havice & Hill, 2012, para. 4).

The Twenty-first Century Leadership Academy Program

> This is a program designed to create tomorrow's most successful and respected technology and engineering leaders, consultants, and strategic thinkers. As leaders, we need to create the future. This program incorporates knowledge and experiences from education leaders and other experts using practical and innovative advice on how leaders make a difference. Participants are involved in important dialogue using the best wisdom from experts and practitioners across sectors of the profession.
>
> The aim of the program is to help technology and engineering educators gain additional skills to better deal with issues of performance, how systems and associations work, the role of finances in decision-making, and how to merge ideas and ambitions in a positive manner. The 21st CLA program provides a balance of practical and inspirational ideas to individuals who want to be leaders in the association and profession. (Havice & Hill, 2012, para. 2-3).

With the continued preparation of new doctoral graduates with focused study in the preparation of technology and engineering educators and the added benefits some of these graduates have gained through participation in the Twenty-first Century Leadership Academy Program, the researchers sought to determine the perspectives of these new professionals about the future of the school subjects technology and engineering education. (The researchers are not aware of any prior studies on this topic.) This study was designed during summer 2012 and administered in the fall of 2012. The researchers identified 59 new doctoral graduates who were prepared during the past five years in this teaching area. The researchers believe this population represents most (95-98%) graduates awarded doctoral degrees during the past five years in this field. This is based on: (a) information from program leaders at universities that offer doctoral degree programs with concentrated study in technology and engineering education, (b) a list of fellows who completed degree work through support of the National Center for Engineering and Technology Education, and (c) a list of participants who took part in ITEEA's Twenty-first Century Leadership Academy Program.

Research Design

The researchers selected the survey method, a nonexperimental quantitative research tool, as the research design for the study. Fraenkel, Wallen, and Hyun (2012) identified the survey as a method to "describe the characteristics of a population" (p. 393). These authors noted that in other types of research "the population as a whole is rarely studied" (p. 393), the survey method allows for a "carefully selected sample of respondents" (p. 394) to be surveyed, and a "description of the population is inferred from what is found out about the sample" (p. 394). For purposes of this study, a cross-sectional survey was administered to gather information from a predetermined population at a predetermined point in time. Gay, Mills, and Airasian (2012) noted that cross-sectional designs are "effective for providing a snapshot of the current behaviors, attitudes, and beliefs in a population" (p. 185). Creswell (2012) stated that a cross-sectional survey design has the "advantage of measuring current attitudes or practices" (p. 377).

Procedure

The researchers administered a structured 12-question survey (followed by 5 demographic-related questions) using SurveyMonkey™. Wiersma and Jurs (2009) underscored the importance of collecting demographic data in terms of classifying variables for further analysis. Gay et al. (2012) stated the importance of designing surveys that are brief, easy to respond to, and address a specific research topic. The survey for this study was administered in November 2012; two additional follow-up letters were sent to the invitees. In order to ensure anonymity of the participants, a URL to the survey was provided in the initial letter of invitation to participate and in follow-up letters. At no time during the conduct of the study did the researchers know which participants did or did not respond to the survey. In the final analysis, 34 of the 56 invitees or 60.7% selected to respond (correct email addresses could not be identified for three graduates). Although the response rate is not statistically significant (Patten, 2012), the information provided by the respondents was revealing because it provided clues about the health, vitality, and possibly the future of the technology and engineering education teaching profession as seen through the lens of recent doctoral graduates. No incentives were provided to the participants, and they were reminded in their letter of invitation to participate that there were no direct benefits to them by participating. Finally, invitees were informed that their responses would be aggregated with the responses from all other participants, so there would be minimal risk to them as a participant.

Prior to commencing the study, the researchers assumed that the participants were capable of identifying (a) the focus of content taught in a formalized K-12 technology and engineering education program, (b) methods of future teacher preparation, (c) characteristics of their professional involvement, and (d) future forecasting for their school subject. The researchers also assumed the participants understood the intent of each survey question and their responses to the questions would reflect their individual insights and perspectives about the profession. Finally, the researchers assumed that each survey question contained only one idea or question, used neutral (unambiguous) language so as not to lead a respondent to respond in a specific way, and contained response options that were simple, clear, and consistent.

Findings

The population for this study was a group of recent doctoral graduates ($N = 34$) who were nominated by lead professors at seven universities that offer the doctoral degree in technology and engineering education or the graduates were in a specialized sponsored program. For example, a qualified doctoral graduate was one who graduated (Ph.D. or Ed.D.) within the past five years from one of the following institutions: Colorado State University, North Carolina State University, Old Dominion University, The Ohio State University, The University of Georgia, Utah State University, and Virginia Polytechnic and State University. Some graduates may have completed their degrees under the auspices of the National Center for Engineering and Technology Education (NCETE) and may not be part of the seven purposely selected institutions. Finally, some graduates participated in the International Technology and Engineering Educators Association's (ITEEA) Twenty-first Century Leadership Academy Program and graduated from one of the purposely selected institutions and/or participated in the NCETE program. In a select few cases, a participant in the study may have been involved in more than one of the preceding categories. The researchers collected demographic data from the participants, and analyses of the data are provided in Table 1.

Data were gathered and analyzed from the participants' responses to the 12 survey questions. Part 1 of the survey focused on what is currently happening in the profession – the "here and now" – and the role the participants currently serve in their profession; Part 2 focused on the future of the profession from the participants' perspectives. A summary of the data for Part 1 of the study is first reported, followed by a summary of the data for Part 2.

Part 1

When asked to identify what should be the focus of content taught in a formalized K-12 technology and engineering education program, the participants were provided five choices to

Table 1. Population Demographics

Demographic	Selection	Number	Percent
Gender (*n* = 33)	Female	7	21.2
	Male	26	78.8
Age (*n* = 33)	20-30	1	3.0
	31-40	16	48.5
	41-50	8	24.2
	51-60	7	21.2
	61+	1	3.0
Area of Professional Interest (*n* = 33)	Post-Secondary	16	48.5
	High School	11	33.3
	Middle School	3	9.1
	Elementary School	3	9.1
Current Position (*n* = 26)	Teacher Educator	15	57.7
	Elementary Teacher	6	23.1
	Supervisor	2	7.7
	Private Sector	2	7.7
	Full-Time Student	1	3.8
CTETE 21st Century Leader Program Participant (*n* = 33)	Yes	18	54.5
	No	15	45.5

Note: *N* = 34. One respondent chose not to answer the demographic questions. It appears that eight participants work in the private sector by not selecting a response for current educational positions.

select from, and they were instructed to select "all that apply." Any participant could select one or more responses from the following choices: technological literacy, workforce education, engineering education, STEM integration, and "other." All 34 participants responded to the question. Twenty-five or 73.5% of the responses indicated the focus should be on technological literacy, 24 or 70.6% indicated the focus should be on STEM integration, 20 or 58.8% indicated the focus should be on engineering design, and 14 or 41.2% indicated the focus should be on workforce education. Three responses were recorded for the "other" category, and those written comments focused on content that might be included within the curriculum.

The second question focused on instructional strategies and what should be the focus of these strategies in a formalized K-12 technology and engineering education program. The researchers provided the participants four choices, and they were instructed to select "all that apply." The four choices were project-based, design-based, contextual, and "other." All 34 participants responded to the question. The project-based instructional strategy received the highest response at 85.3%, whereas designed-based was selected by 64.7% and contextual was selected by 61.8% of the participants. The "other" category was selected by five participants, and their responses included strategies such as inquiry-based, problem-based, hands-on (real world design and build), problem solving-based, and contest-based.

The researchers then focused on having the participants identify the primary audience for a formalized instructional program in technology

Table 2. Part 1, Current Activity within the Profession

Item	Selection	Number	Percent
1. Content for K-12 T/E Ed. (*n* = 34)	Technological Literacy	25	73.5
	Workforce Education	14	41.2
	Engineering Design	20	58.8
	STEM Integration	24	70.6
2. Focus of Instructional Strategies (*n* = 34)	Project-based	29	85.3
	Design-based	22	64.7
	Contextual	21	61.8
3. Primary Teaching Audience (*n* = 34)	Elementary School	1	02.9
	Middle School	2	05.9
	High School	3	08.8
	Secondary School	10	29.4
	Post-Secondary School	0	00.0
	All Levels	18	23.9
4. Journals Regularly Read (*n* = 29)	*Technology and Engineering Teacher*	23	79.3
	Children's Technology and Engineering	6	20.7
	Prism Magazine	6	20.7
	Journal of Technology Education	23	79.3
	Journal of Technology Studies	7	24.1

Note: *N* = 34. These numbers exceed the *N* value and 100%, since respondents could select more than one choice for these questions.

and engineering education. The participants were instructed to "select only one" from the following categories: elementary school students, middle school students, high school students, secondary students (middle and high school), post-secondary students, and all of the above identified populations. All 34 participants responded to the question. The participants believe that all elementary, middle, high school, and post-secondary students should be the primary audiences as this category was acknowledged by 53.9% of the participants. Only 29.4% of the participants selected secondary students (middle and high school) as the primary audience.

Professional publications provide members with a vehicle to share and gain new knowledge and to add to the knowledge base in their discipline. The researchers asked the participants which professional publications best described them as a regular reader of those publications. Interestingly, of the 34 individuals who participated in the study, five individuals chose to skip this question and not respond. Of those individuals who responded, two publications received the highest response. *The Technology and Engineering Teacher* and the *Journal of Technology Education* were each selected by 79.3% of the respondents. *The Journal of Technology Studies* was selected by 24.1% of the respondents and *Children's Technology and Engineering* and *Prism Magazine* were each selected by 20.7% of the respondents. Participants were invited to identify other publications that were not part of the forced choices. *The Journal of Engineering Education, Journal of Learning Sciences, International Journal of Technology and Design Education*, and CTETE yearbooks were each identified. Table 2 summarizes data on the perceptions of recent doctoral graduates regarding current activities within the technology and engineering education professions.

Part 2

Part 2 of the survey instructed the participants to project to the year 2025 and then respond to a series of questions that focused on the future of the profession. For example, the researchers asked the participants to focus on teacher certification and how future technology and engineering educators will become certified (licensed) as classroom teachers. Thirty-two of the 34 participants responded to this question. The participants were instructed to select only one descriptor from the following statements and the response rate and n value follow each statement. Some chose to clarify their selection through the "other" category.

- A 4-year campus-based program, much like we have today in education; 40.6%, $n = 13$
- A 5-year campus-based program, with a major in industrial technology, engineering, or other similar major; 18.8%, $n = 6$
- Licensure add-ons to an existing degree program; 28.1%, $n = 9$
- Documenting academic qualifications through professional certification testing; 12.5%, $n = 4$
- Other; $n = 6$. Hybrids of the above options were mentioned, including combinations that entailed focus on STEM education.

Once the participants indicated how future teachers would be certified or licensed, they were then asked "where" they will receive their certification and teacher training. Thirty-three of the 34 participants responded to this question, and they could select "all that apply" from the following statements. The response rate and n value follow each statement.

- In brick and mortar university classroom/laboratories; 54.5%, $n = 18$
- Via distance learning technologies; 27.3%, $n = 9$
- Hybrid systems that involve blended methods of instructional delivery; 75.8%, $n = 25$
- Through an external testing organization; 0.0%, $n = 0$
- Other; 6%, $n = 2$. Both thought that online training was a poor option for the preparation of teachers.

Once teachers are certified, professional development becomes an important part of their tenure as a teacher. The researchers asked the participants to identify where technology and engineering practicing teachers will receive their professional development. Thirty-three of the 34 participants responded to this question, and they could select "all that apply" from the following statements. The response rate and n value follow each statement.

- State/district/city supervisors; 51.5%, $n = 17$
- Commercial vendors; 27.3%, n = 9
- National professional associations; 63.6%, $n = 21$
- State professional associations; 45.5%, $n = 15$
- Local professional associations; 33.3%, $n = 11$
- Teacher education institutions; 69.7%, $n = 23$
- Distance learning providers; 33.3%, $n = 11$
- Other; 0%

Historically, professional associations played a key role in serving the members they represent. Arguably, some associations are the lifeblood of their professions. The researchers sought to identify the professional associations that participants thought they would be members of in 2025. Thirty-two of the 34 participants responded to this question, and they could select "all that apply" from the following statements. The response rate and n value follow each statement.

- ASEE – American Society for Engineering Education; 68.8%, $n = 22$
- ITEEA – International Technology and Engineering Educators Association; 75%, $n = 24$
- CC of ITEEA – Children Council of ITEEA; 18.8%, $n = 6$
- CSL – Council for Supervision and Leadership of ITEEA; 12.5%, $n = 4$
- CTETE – Council on Technology and Engineering Teacher Educators of ITEEA; 50.0%, $n = 16$
- State-level Technology and Engineering Associations; 43.8%, $n = 14$
- STEM Associations (e.g., NSTA – National Science Teachers Association, NCTM – National Council of Teachers of Mathematics); 56.33%, $n = 18$
- Other; 21.8%, $n = 7$. Some of the respondents selected other associations that are related to technical professions but whose mission may not necessarily be directly supportive of education. This may show that not all who complete these specific degrees pursue employment within educational fields.

Being a member of a professional association does not necessarily imply that this person attends meetings of that association. The researchers sought to identify which association conferences the participants would be attending in 2025. Twenty-nine of the 34 participants responded to this question, and they could select "all that apply" from the following statements. The response rate and n value follow each statement.

- ASEE – American Society for Engineering Education; 62.1%, $n = 18$
- ITEEA – International Technology and Engineering Educators Association; 79.3%, $n = 23$
- PATT – Pupils Attitudes Towards Technology; 13.8%, $n = 4$
- State-level technology and engineering conferences; 58.6%, $n = 17$
- TERC – Technology Education Research Conference; 17.5%, $n = 5$
- Other; 31%, $n = 9$. Others included Mississippi Valley Conference, Southeastern Technology Education Conference, International Society for Technology Education, Association for Career and Technical Education, and others.

People join professional associations for a variety of reasons. For example, some may join to receive a publication, while others join because they want to attend meetings. Still others join so that they might publish in the journal of that association. The researchers inquired as to the publications the participants would be publishing in by 2025. Thirty of the 34 participants responded to this question, and they could select "all that apply" from the following statements. The response rate and n value follow each statement.

- *Technology and Engineering Teacher*; 73.3%, $n = 22$
- *Journal of Technology Education*; 86.7%, $n = 26$
- *Journal of Technology Studies*; 30%, $n = 9$
- *International Journal for Technology and Design Education*; 40%, $n = 12$

- *Australiasian Journal of Technology Education*; 3.3%, n = 1
- *Prism Magazine*; 10%, n = 3
- Other; 40%, n = 12. A number of participants listed many of the above journals plus others, including *Journal of Engineering Education* (3 responses), *Children's Engineering and Technology* (3 responses), and *Journal of STEM Education* (2 responses).

Table 3 provides a summary of perspectives of doctoral graduates related to the future of the profession.

The researchers inquired what the participants foresee as their role in the profession in the year 2025. They were provided some descriptive statements that represent different levels of activity. Thirty-two of the 34 participants responded to the question, and they could select "all that apply" from the following statements. The response rate and n value follow each statement.

- I believe I will hold or have held key leadership positions in ASEE – American Society for Engineering Education; 43.8%, n = 14
- I believe I will hold or have held key leadership positions in CC of ITEEA – Children Council of ITEEA; 25%, n = 8
- I believe I will hold or have held key leadership positions in CSL – Council for Supervision and Leadership; 12.5%, n = 4
- I believe I will hold or have held key leadership positions in CTETE – Council for Technology and Engineering Teacher Educators; 37.5%, n = 12
- I believe I will hold or have held key leadership positions in ITEEA – International Technology and Engineering Educators Association; 56.3%, n = 18
- I believe I will hold or have held key leadership positions in state-level technology and engineering education associations; 50%, n = 16
- I believe I will hold or have held key leadership positions in STEM Associations (e.g., NSTA – National Science Teachers Association, NCTM – National Council of Teachers of Mathematics); 34.4%, n = 11
- I do not envision myself serving in key leadership positions in professional associations; 6.3%, n = 2

Finally, the last question, but maybe the most important question: what did the participants project as the future of the technology and engineering education profession by the year 2025. Thirty-three of the 34 participants responded to the question, and they could select "only one" statement from the following choices.

- The profession will look very similar to what it looks like today; that is, it will be a vibrant profession with a core of members who are able to sustain it; 30.3%, n = 10
- The profession as we know it today will be replaced by STEM; 39.4%, n = 13
- The profession will be integrated into the science profession; 18.2%, n = 6
- Technology and engineering education will disappear as a school subject; 12.1%, n = 4

Discussion and Conclusions

What did we learn when we sought the informed opinions of what may be the next generation of individuals to lead this profession? Did these individuals identify some new directions for this profession? Did they reinforce the need to support the initiatives that the profession's leaders are currently pursuing? The researchers believe that data provided by the participants in this study provide much insight about current and future initiatives and it behooves the profession's leaders, current and future, to be apprised of what the next generation is suggesting.

As data from this study were reviewed, analyzed, and synthesized, the researchers reached several conclusions. First, there is general agreement among the participants that technological literacy, STEM integration, and engineering design are important foci for content taught in formalized K-12 technology and engineering education programs. Each one of these foci is identified by more than 50% of the participants in the study. This conclusion

Table 3. Part 2, Future of the Profession

Item	Responses	Number	Percent
5. Teacher Certification Pathways	4-year campus program	13	40.6
	5-year campus program with industry/engineering major	6	18.8
	License add-on	9	28.1
	Certification testing	4	12.5
6. Certification and Training Options	On university campus	18	54.5
	Via distance learning	9	27.3
	Hybrid delivery system	25	75.8
	Testing organization	0	00.0
7. Professional Development Providers	State/district supervisors	17	51.5
	Commercial vendors	9	27.3
	National professional associations	21	63.6
	State professional associations	15	45.5
	Local professional associations	11	33.3
	Teacher education institutions	23	69.7
	Distance learning providers	11	33.3
8. Member of which Professional Organization	ASEE	22	68.8
	ITEEA	24	75.0
	Children's Council (ITEEA)	6	18.8
	Council for Supervision and Leadership (ITEEA)	4	12.5
	Council for Teacher Educators (CTETE)	16	50.0
	State-level technology and engineering association	14	43.8
	STEM associations	18	56.3
9. Conference Attendance	ASEE	18	62.1
	ITEEA	23	79.3
	PATT	4	13.8
	State level	17	58.6
	TERC	5	17.2
10. Publications You Would Seek to Publish	*Technology and Engineering Teacher*	22	73.3
	Journal for Technology Education	26	86.7
	Journal of Technology Studies	9	30.0
	International Journal for Technology and Design Education	12	40.0
	Australasian Journal for Technology Education	1	03.3
	Prism Magazine	3	10.0

Note: $N = 34$. Respondents could have more than one response to questions posed.

is supported in the literature (Bybee, 2013; ITEA, 2000; Wicklein, 2006). Second, there is also general agreement on what should be the foci of instructional strategies offered in formalized K-12 technology and engineering education programs. Project-based, design-based, and contextual learning experiences were identified by more than 50% of the participants as important foci of instructional strategies. Third, the audience for engineering and technology education has been a topic of discussion since the subjects' inception. The participants' responses further underscored that the primary "audience" may continue to be a topic of discussion well into the future. The only descriptor selected by more than 50% of the participants was "all of the above," which simply extends the conversation on who these programs are designed to serve. This conclusion is also supported by the ITEA (2000) and Ritz (2011). Fourth, the researchers attempted to determine which publications the participants regularly read as part of their professional growth and development. It was clear that the only two publications were commonly identified in the current technology and engineering education environment: *Technology and Engineering Teacher* and *Journal of Technology Education*. Both publications were read regularly by 79.3% of the respondents.

Fifth, the researchers wanted to find out how future technology and engineering educators will become certified (licensed) as classroom teachers. There was no agreement among the participants. The 4-year campus-based program received the highest response rate (40.6%). Of those participants who chose the "other" category, there was no agreement in their written responses. Sixth, when asked where classroom teachers will receive their certification, hybrid systems involving blended methods of instructional delivery received the greatest response (75.8%), and 54.5% of the participants believed that certification and training would occur in brick and mortar university classroom/laboratories. Do the responses to this question reveal important information about the future of our delivery systems in technology and engineering education? Do institutions and professors need to get more aggressive in designing alternative delivery modes of instruction? Seventh, once we learned the participants' perspectives on how future teachers will be certified, future teachers must engage in continuous professional development. The participants believed that professional development would be provided by the national professional associations (63.6%). This is surprising because our national professional associations are experiencing a decline in membership and a decline in conference attendance. The participants (51.5%) thought that state/district/city supervisors would provide professional development, but once again, many states/districts/cities have either consolidated their supervisory positions or eliminated them to cut costs. Commercial vendors, state professional associations, and local professional associations did not meet the greater than 50% threshold established by the researchers to be considered as a viable alternative to providing professional development. These findings are also supported by those of Devier (1999), Karseth and Nerland (2007), and Leahy (2002). Eighth, the long-term viability of professional associations is always a concern of the leaders of these associations and to the associations' membership (Martin, 2007; Reeve, 1999). Strong membership levels are vitally important to our associations. Will the participants of this study be members of professional associations in 2025 that exist today? Three associations received greater than 50% responses from the participants: ITEEA (75%), ASEE (68.8%), and STEM associations (56.3%). The researchers did not find the selection of ITEEA, ASEE, and STEM associations surprising; however, CTETE did not meet the greater than 50% threshold. It was surprising that the association that has been historically associated with doctoral graduates was not to be viewed as a future association of the graduates. Ninth, it appears that participants in this study will be regular conference attendees of their professional associations' conferences: ITEEA (79.3%), ASEE (62.1%), and state-level technology and engineering conferences (58.6%). Not surprising to the researchers, the two association conferences (TERC and PATT) that are hosted outside the United States received only a small amount of attention from the participants. Tenth, the researchers asked the participants which professional publications they planned to publish in by 2025. Two publications, *Technology and Engineering Teacher* (73.3%) and *Journal of Technology Education* (86.7%)

exceeded the greater than 50% threshold established by the researchers. Surprisingly, even though 68.8% of the participants plan to be members of the ASEE, only 10% envisioned publishing in *Prism Magazine* by 2025.

Individuals who select to serve in leadership positions in their professional associations provide a valuable service to their members. Surprisingly, except for ITEEA, which received a response rate of 56.3%, participants in the study do not envision themselves serving in key leadership positions. Where will our professional associations find individuals to serve in key leadership positions? It appears these individuals may not come from the population represented in this study. Finally, and maybe the most important question asked in this study, what is the future of the technology and engineering education profession? Unfortunately, there is no clear agreement among the participants in this study. The participants were divided as to whether the profession as we know it today will (a) be replaced by STEM, (b) be very similar to what it looks like today, or (c) be integrated into the science school subjects. Will technology and engineering education disappear as school subjects? Of the participants, 12.1% believe they will disappear.

Recommendations for Further Research

The population for this study was a group of recent doctoral graduates (N = 34). It is clear they provided valuable information that may ultimately lead to substantive discussions about the core principles that guide the profession. Future researchers may wish to consider the findings of this study and develop a new and improved set of data. They may also wish to expand the size of the sample to include other populations to ascertain the professional judgments of a broader audience of practicing technology and engineering educators. Researchers may also wish to further dissect the findings of the study, delve more deeply into the current findings of one or more questions for deeper meanings and understandings, and/or simply pose the same questions via a different voice. Finally, researchers may wish to conduct a qualitative study that leads to in-depth interviews and a more in-depth analysis of the participants' initial responses.

Summary

The researchers selected the survey as the research design of choice to solicit specific information from a group of purposely selected graduates of doctoral degree granting institutions. The participants' responses to the survey questions provide quality information about the future of the technology and engineering education professions. In addition, information gleaned from this study may be helpful to professional leaders as they develop their strategic plans and make strategic decisions about the technology and engineering education subjects.

What was learned from this study? In some cases the participants were comfortable with the present direction of their profession. Their responses to other questions, however, left the researchers somewhat puzzled about this profession's future and their roles in that future. For example, they believe in the future of ITEEA and they feel comfortable with its two primary publications, but they do not necessarily feel comfortable with the teacher education affiliate (CTETE) of ITEEA. Participants plan to attend conferences of other professional associations, but they do not see themselves necessarily publishing in the literature of those same associations or leading those associations by holding key leadership positions. Finally, there was no consensus about the future of technology and engineering education in the year 2025. The larger message of the survey to all in this profession is the following uncertainty: Should we be alarmed by the message these graduates conveyed to us?

Dr. John Ritz is Professor in the Department of STEM Education and Professional Studies at Old Dominion University, Norfolk, VA. He is a member of the Alpha Upsilon Chapter of Epsilon Pi Tau and holds a Laureate Citation.

Dr. Gene Martin is Professor and Graduate Secondary Education Program Coordinator in the Department of Curriculum & Instruction at Texas State University, San Marcos, Texas. He is a member of the Alpha Mu Chapter of Epsilon Pi Tau and has been awarded both the Laureate and Distinguished Service Citations.

References

Alotaibi, M. (2007). Factors affecting nurses' decisions to join their professional association. *International Nursing Review*, *54*, 160-165.

Bauman, S. (2008). To join or not to join: School counselors as a case study in professional membership. *Journal of Counseling & Development*, *86*, 164-177.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. Arlington, VA: National Science Teachers Association.

Creswell, J. W. (2012). *Educational research* (4th ed). New York: Pearson.

Devier, D. H. (1999). Fostering a professional culture in technology education. In A. F. Gilberti & D. L. Rouch, *Advancing professionalism in technology education* (pp. 251-270). New York: Glencoe McGraw-Hill.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education* (8th ed). New York: McGraw-Hill.

Gaff, J. G. (2002). Preparing future faculty and doctoral education. *Change, 34*(6), 63-66.

Gay, L. R., Mills, G. E., & Airasian, P. (2012). *Educational research* (10th ed). New York: Pearson.

Gilberti, A. F. (1999). The need for professionalism in technology education: Challenges for the future. In A. F. Gilberti & D. L. Rouch, *Advancing professionalism in technology education* (pp. 1-12). New York: Glencoe McGraw-Hill.

Havice, W., & Hill, R. (2012). Foundation for technology and engineering education, international technology and engineering educators association, and council on technology teacher education 21st century leadership academy. Retrieved from: http://www.iteea.org/Membership/21CenturyLeaders/LeadershipAcademyApplication2014.pdf

International Technology Education Association (ITEA). (2000). *Standards for technological literacy: Content for the study of technology*. Reston, VA: Author.

Karseth, B., & Nerland, M. (2007). Building professionalism in a knowledge society: Examining discourse of knowledge in four professional associations. *Journal of Education and Work*, 20, 335-355.

Leahy, M. J. (2002). Professionalism in rehabilitation counseling: A retrospective review. *Journal of Rehabilitation Administration, 26*, 99-109.

Martin, B. (2007). A closer look at three association super-trends. *Journal of Association Leadership*. Retrieved from: http://www.asaecenter.org/PublicationsResources/ JALArticleDetail.cfm?itemnumber=25246

Meltzer, M. (1996). Promoting professionalism. *Atlanta Business Chronicle*. Retrieved from: http://cgi.amcity.com/atlanta/stories/111896/focus1.html

Moye, J. J. (2009). Technology education teacher supply and demand—a critical situation. *The Technology Teacher*, 69(1), 30-36.

Patten, M. L. (2012). *Understanding research methods*. Glendale, CA: Pyrczak Publishing.

Phillips, B. N., & Leahy, M. J. (2012). Prediction of membership in rehabilitation counseling professional associations. *Rehabilitation Counseling Bulletin, 55*(4), 207-218.

Putnam, R. D. (2000). *Bowling alone*. New York: Simon & Shuster.

Reeve, E. M. (1999). Professional associations, organizations & other growth opportunities. In A. F. Gilberti & D. L. Rouch, *Advancing professionalism in technology education* (pp. 69-96). New York: Glencoe McGraw-Hill.

Richlin, L., & Essington, A. (2004). Faculty learning communities for preparing future faculty. *New Directions for Teaching and Learning, 97*, 149-157.

Ritz, J. M. (2011). A focus on technological literacy in higher education. *The Journal of Technology Studies, 37*(1), 31-40.

Rouch, D. L. (1999). Professionalism and leadership in technology education. In A. F. Gilberti & D. L. Rouch, *Advancing professionalism in technology education* (pp. 15-32). New York: Glencoe McGraw-Hill.

Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization*. New York: Doubleday.

Wicklein, R. C. (2006). Five good reason for engineering design as the focus for technology education. *The Technology Teacher, 65*(7), 25-29.

Wiersma, W., & Jurs, S. G. (2009). *Research methods in education* (9th ed). Boston: Allyn and Bacon.

Yeager, S. J., & Kline, M. (1983). Professional association membership of nurses: Factors affecting membership and the decision to join an association. *Research in Nursing & Health, 6*, 45-52.

Feasibility Assessment of Using the KIP System to Achieve an Energy-Savings Potential for an Electronic Marquee

By Wen-Fu Pan, Shih-Chun Tu, Mei-Ying Chien, and Ya-Moo Zhang

Abstract

Conventional electronic marquees continue to consume energy even without a human presence. The purpose of this study is to assess energy-savings potential via the installation of the Kinect and IP Power integrated system (KIP) on an electronic marquee; this system will transfer the consumption data for total electricity to electricity-monitoring software (EZ-HD) using a smart meter (EZ-RE) and the ZigBee USB Dongle. An experiment was conducted at one school entrance for two periods during 10 school months, and it was found that the hourly electricity consumption rate for the original electronic marquee system was 1.25 kWh. After the KIP system was installed, the electronic marquee was activated only during human presence, and the hourly electricity consumption rate was 0.97 kWh, providing an average electricity savings rate of 22.4%. The results suggest that the KIP system can help to reduce the consumption of electricity for electronic marquees. Compared to infrared sensor parts used in the past as power switches for electronic equipment, the advantage of the KIP system is that it can distinguish a human presence and would not be interfered by moving objects or animals. In addition, the KIP system has a wider detection range and allows the users to program and detect different electricity-saving contexts and configurations for electronic equipment in different venues according to their individual needs. Therefore, through this test and assessment, we suggest that it is feasible to apply the KIP system in automatic lighting devices, televisions, air conditioners, or security monitoring systems.

Keywords: Electricity-Savings Designs; IP Power; Kinect; Smart Meters

Introduction

For a long time, reducing electricity and energy use has been a primary strategy for reducing the consumption of global energy and carbon emissions; thus, the research related to designing architectural spaces with electricity-savings effect has always received strong attention (Harvey, 2009). For example, regarding electricity-efficient or electricity-savings building materials, Sadineni, Madala, and Boehm (2011) compared the electricity-savings potential of trombe, ventilated, and glazed wall materials, and they found that air tightness and infiltration of the materials were critical factors that influenced electricity savings. Sadineni et al. (2011) suggested that if the factors of electricity-savings materials were considered prior to construction, no additional reinvestment of electricity-savings costs would be needed. Regarding indoor air conditioning, Ali and Morsy (2010) compared the electricity-savings potential of 290 W radiant panel heaters and 670 W conventional portable convective heaters, and found that when the outdoor temperature was 10°C, the 290 W radiant panel heaters provided more comfort and saved approximately 56.7% in energy consumption. In addition, Shehabi, Masanet, Price, Horvath, and Nazaroff (2011) studied and tested several large-scale U.S. data center buildings; the results suggested that the local climate, the used airflow management, and proper control sequences were the factors that could be used to potentially save electricity. Their research results also demonstrated that average data center buildings could save 20% to 25% in electricity or energy consumption, and that the server rooms of data centers could save nearly 30% in electricity or energy consumption, amounting to a savings of 1.3 to 1.7 billion kWh of electricity annually.

Although energy-savings architectural space design is an effective energy-savings strategy, other studies have investigated how the billing methods of the household micro-energy generation may influence the energy-savings effect. Darghouth, Barbose, and Wiser (2011) studied 200 households that used two power companies in California as samples and compared the electricity-savings potential of net metering and feed-in tariff. Because most electricity meters in the United States can be measured using two-way measurement (electricity generation and consumption), a net metering policy was implemented to allow users to deduct a portion of the fee from their electricity bills based on the amount of electricity sold. The study conducted by Darghouth et al. (2011) showed that net metering had a better electricity-savings effect than feed-in tariffs, indicating that if electricity-generation income could instantly be reflected in electricity use or electricity expenditure reductions, the users would be more willing to reduce electricity consumption costs.

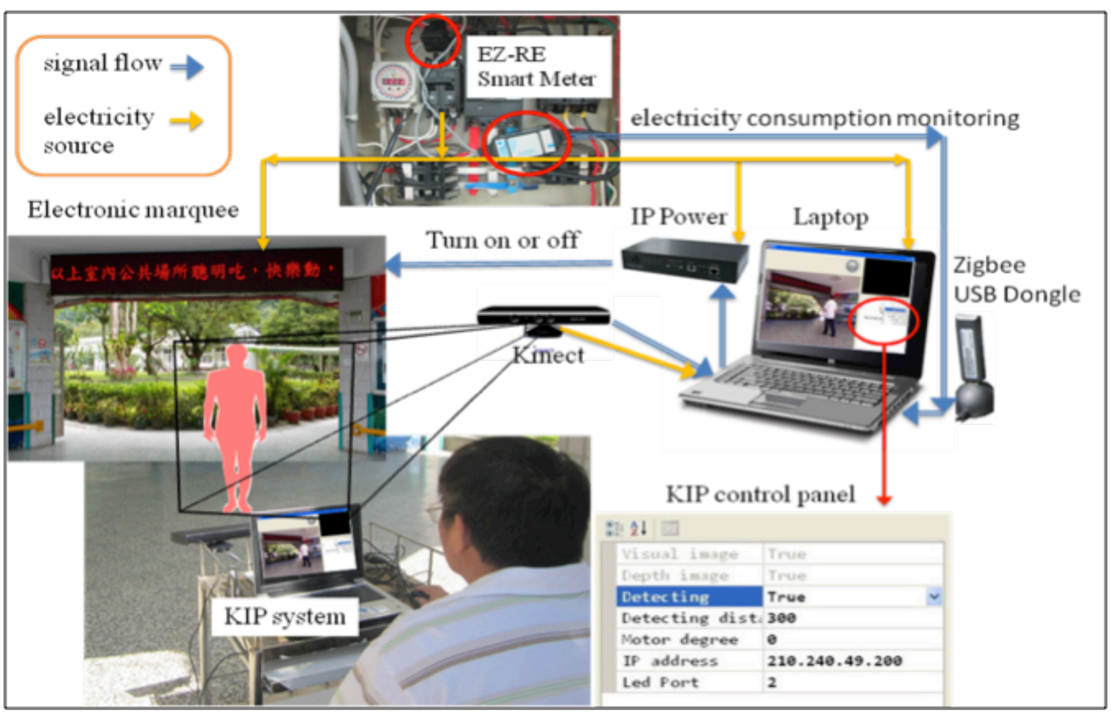
The above mentioned two-way measurements did not provide users access to monitoring and managing their electricity-consumption data. The smart meter is a new digitized electricity-consumption measuring system, which can accurately show electricity usage amounts and return or feedback electricity usage information through the Internet. The research institution In-Stat has estimated that by 2016 smart meters could create a global production value of approximately USD $1.2 billion (Business Wire, 2011). One especially thriving factor for producing this smart meter is its incorporation of the ZigBee wireless sensor network to transmit information. ZigBee is specified as a suite of high-level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks (Rothe & Girhepunje, 2012). For example, market analysis and forecasts as electric utilities provide a ZigBee wireless sensor smart meter to their electricity customers as a home energy-management tool (Sober, 2011). The Ember Corporation (2010) has developed a type of ZigBee wireless sensor smart meter that could be used as a home and commercial electricity monitoring and management system. This corporation also has promoted its smart meter installation plan in Europe; British Gas was the first company approached and employed by Ember to promote this plan. British Gas anticipated that the installation of wireless smart meters would help its 2 million household users to reduce carbon emissions by providing them with access to monitoring their consumption of either electricity or natural gas. ZigBee's wireless sensor networks have received widespread attention from researchers (Egan, 2005; McCain, 2011; Rothe & Girhepunje 2012). The wireless sensor networks are positioned to provide wireless transmission applications such as controlling air conditioning and lighting for residential and commercial areas, and they are designed specifically to replace the continuous increasing independent remote controls (Egan, 2005). Currently ZigBee has several hundred united or allied industries (ZigBee Alliance, 2012).

In this study, we used a ZigBee wireless energy-management system, named EZ-R Series (included EZ-RE smart meter, ZigBee USB Dongle, and EZ-HD software produced by Joseph Technology Co. Ltd.), as a smart meter for collecting electricity-consumption data. The system was designed by installing a Dongle, a USB tool that conformed to ZigBee Protocol, for the reception of electricity-consumption information from EZ-RE smart meter. The energy-management software, EZ-HD, was installed in a laptop to show real-time electricity-consumption information via the ZigBee USB Dongle when electricity-consumption devices were running. The electricity-consumption data on the EZ-HD included energy consumption rates for one day, one month, cumulative months, or cumulative years (Joseph Technology, 2011). In general, the EZ-R Series could only passively collect electricity-consumption information, and it could not actively help consumers reduce the consumption of electricity without the collocation of other electricity-savings spatial designs. A study conducted by Pan, Chien, Liu, and Chan (2012) indicated that Kinect and IP Power integrated systems could improve the accessibility of electronic devices in schools, for example, it could promote interaction between people and electronic devices with sensors to activate or deactivate devices such as air conditioning and lights. Hence, in this study, we further employed the integrated Kinect and IP Power systems (KIP) to design an electricity-savings context to help us assess the real-time interaction between people and electronic marquees at the school entrance area. The KIP system used in this study consisted of a Kinect, a laptop, an IP Power, an OpenNI, a CL_NUI platform, and an OpenNI SDK; we used C# programming language to write and complete the control program for the KIP system. The KIP system was placed at the front side of electronic marquee, and when a person walked into Kinect's sensing area, the Kinect would transmit the sensor data to IP Power in a laptop Windows operating system and activate the IP Power control program, thereby switching on the power source of the electronic marquee.

The current common sensing methods, such as infrared light emitters and sensors, radio frequency identification, Bluetooth, Zigbee, WiFi, GPS, and depth sensors (such as Microsoft Kinect), all have various configurations and techniques involving detection of proximity (Kumaragurubaran, 2011). But regarding the above sensing methods, the infrared (IR) sensor and depth sensor (Kinect) are the only two methods applied in body sensing without a hand-held device (Hill, 2012). Previous studies (Hu, Jiang, & Zhang, 2008; Ma, 2012; Yamtraipat, Khedari, Hirunlabh, & Kunchornrat, 2006) have shown the effects of using IR sensors for saving electricity. However, IR sensor parts are often interfered by passing dogs, cats, or other animals, causing abnormal activation of the devices (Pan, Lin, & Wu, 2011). In contrast, Kinect can distinguish human presence and has a wider sensor range area than IR. Users also can reconfigure them according to individual needs to develop detection contexts for electronic devices required in different venues (Pan, Tu, & Chien, 2012).

Kinect is a human-body sensing input device by Microsoft for the Xbox 360 video game console and Windows, which enables users to interact with the Xbox 360 without the need for a hand-held controller; it is also a 3D depth sensor that integrates three lenses (Pan, Chien, & Tu, 2012). The IP Power system, launched by the AVIOSYS Corporation, can control the power source switches using the Internet and has four power ports, which can independently manage power sources for four electrical devices (Aviosys International Inc., 2011). In this study, we used the source code drivers released by PrimeSense to write a program that controlled the power source switch of the IP power; the operation would enable the electrical device to actively switch its power on or off based on body-sensing, and thereby achieve energy savings by switching off the electrical device when no one was around to use it.

Figure 1. The KIP System Architecture Used to Save Electricity for the Electronic Marquee



Therefore, the purpose of this study was to install a KIP integrated system for the electronic marquee at the gate of one case study school. The EZ-RE electricity meter, Zigbee USB Dongle, and the electricity monitoring software EZ-HD were employed to assess whether the KIP integrated system indeed has energy-savings potential when applied to an electronic marquee.

Methods

Description of the Test Site

The energy-savings test was conducted at one elementary school located in an aboriginal community at eastern Taiwan. The electronic marquee was placed at the school's front gate, which was the only entrance and exit for the school. The school's principal had suspected that rising electricity costs were due to the placement of this electronic marquee. Therefore, we proposed this KIP system and installed it at the front side of electronic marquee to assess whether it would help to achieve energy savings.

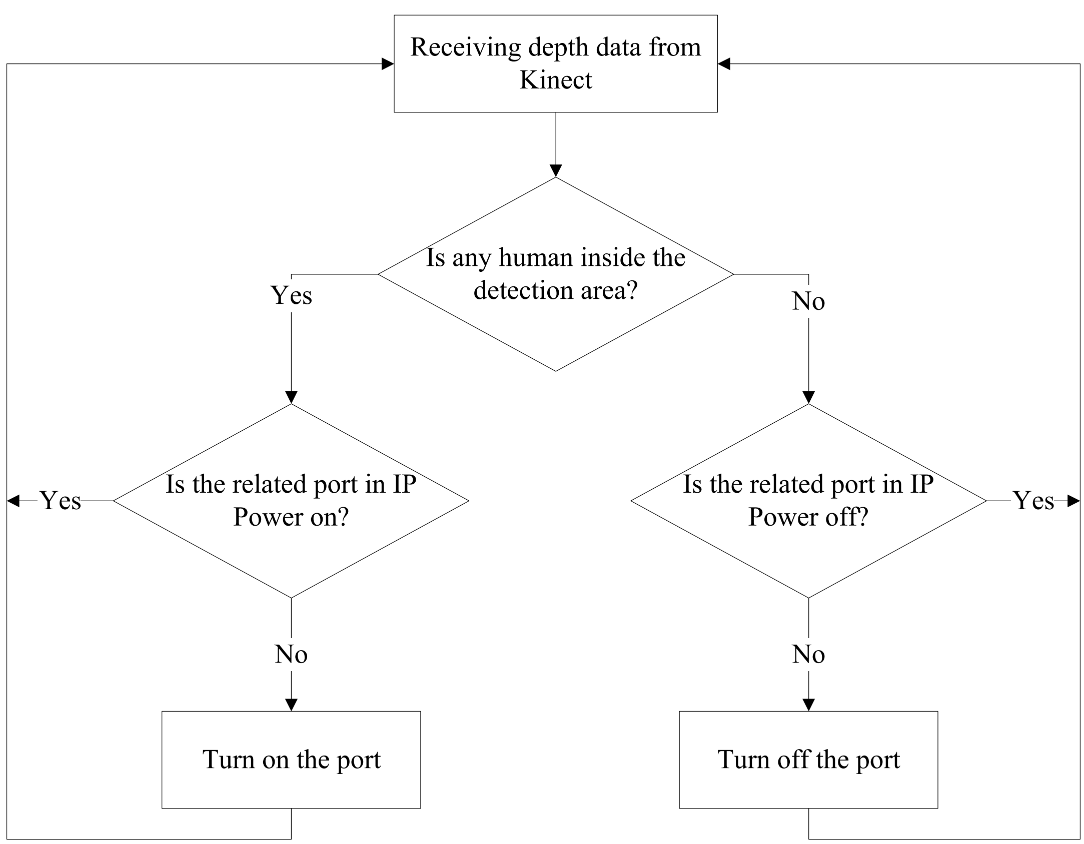
Energy-Savings Architecture of the KIP System

The KIP system architecture used in this study to save energy is shown in Figure 1. The KIP system was placed at the front side of electronic marquee, and when a person walked into the Kinect's sensing area, it would transmit the sensor data to IP Power in a laptop Windows operating system and activate the IP Power control program, thereby switching on the power source of the electronic marquee. Conversely, when no person was present in the Kinect sensing area, the power source of the electronic marquee automatically switched off.

The Software and Hardware of the KIP System

The KIP system used in this study consisted of software and hardware components. The hardware part included the employment of Kinect as depth sensors, a laptop as an operation platform, and an IP Power 9258HP as the remote power switching controller. The software part included the use of OpenNI 5.0.1, CL_NUI

Fig. 2 The information control flow chart of the KIP system



platform 1.0.1210, and OpenNI SDK 1.1.0.41. The OpenNI 5.0.1 was used as the driver to activate Kinect in the Windows operating system; the CL_NUI platform 1.0.1210 was used to activate Kinect's internal motors and enable Kinect to oscillate vertically; the OpenNI SDK 1.1.0.41 was used to write a command program that would translate Kinect's signals into the IP Power's switch functions. In this study, we used C# programming language to write and complete the control program for the KIP system.

The Information Control Flow Chart of the KIP System

Figure 2 shows the information control flow chart of the KIP system. The KIP system used in this study could sense a human presence in the detection area and determine whether the power source for a port on the IP Power should be turned on or off

Using the EZ-RE to Monitor the Electricity Consumption of the Electronic Marquee

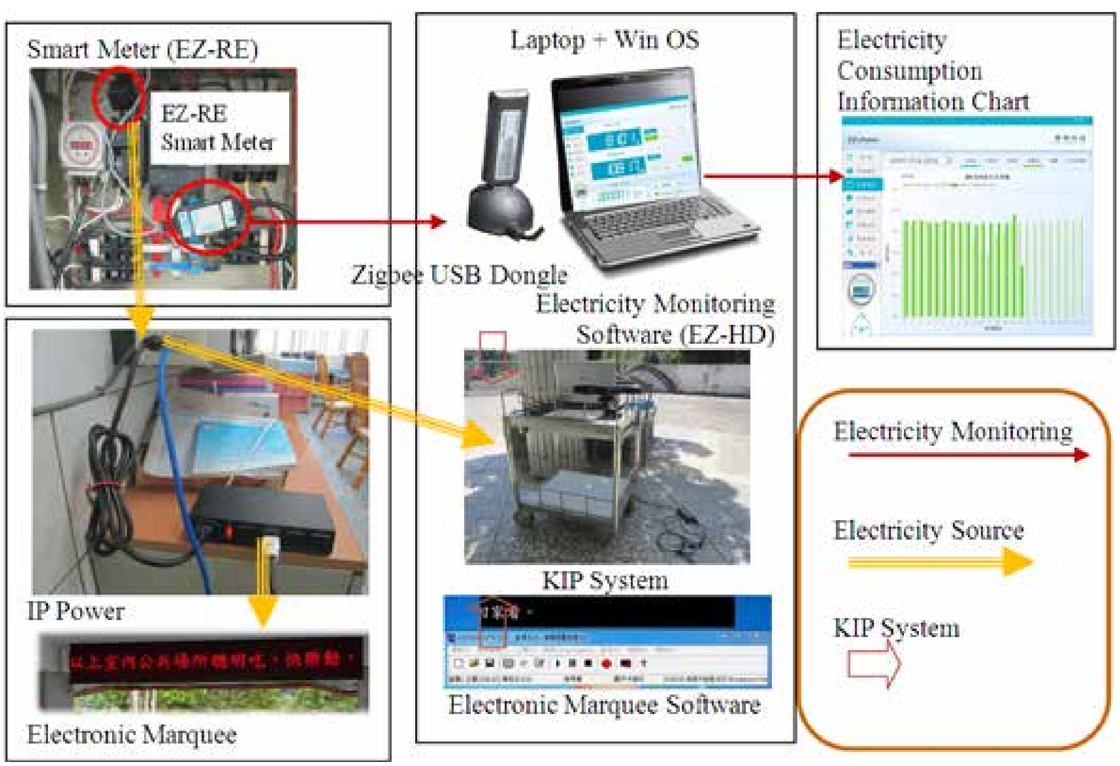
The operational architecture of the EZ-RE smart meter is shown in Figure 3.

The EZ-RE smart meter used in this study provided the functions of measuring current power (W), interval electricity consumption (kWh), and accumulated electricity consumption. An EZ-RE smart meter was used in conjunction with the EZ-HD software and the ZigBee USB Dongle to gather electricity consumption information. The electricity-consumption data gathered from laptop, IP Power, and electronic marquee was measured via EZ-RE smart meter and transmitted via ZigBee USB Dongle to the EZ-HD energy management software. The electricity- consumption data of EZ-HD showed the yearly, monthly, and daily electricity usage, so the data could be converted into statistical information (with or without KIP installed).

The Measurement of Electricity Consumption during Peak and Non-Peak Hours

This study used the electricity consumption of 1.25 kWh for its measurement on May 4, 2012, between 6:30AM and 7:30AM (including the electricity consumption of the accompanying laptop but without KIP system) as the basis for the per-hour electricity consumption rate of the electronic marquee. After we installed the KIP system to the electronic marquee, we continuously measured the electricity consumption rates (kWh) for 10 school months starting on February 2012 at peak hours

Figure 3. The Operational Architecture of the EZ-RE Smart Meter



(6:30AM to 7:30AM) and non-peak hours (9:00AM to 10:00AM). The peak and non-peak hours defined by this study were based on the school routine and the information given by school teachers. In spite of the change of seasons, people passing through the school entrance stayed regular at peak and non-peak hours. Therefore, the researchers simply chose 10 school months to test the electronic marquee with KIP system.

Comparison of the Electronic Marquee's Electricity Consumption Before and After the KIP Installation

Before the KIP system was installed on the electronic marquee, the hourly electricity consumption rate for the electronic marquee (including the electricity consumption of a laptop installed with marquee software) was measured as 1.25 kWh. With the KIP system installation, the electronic marquee power source was activated only when a person was nearby or in the marquee sensor zone, and it would automatically deactivate when no person was nearby or when people left the sensor zone. The electricity-consumption calculation method for the electronic marquee using the KIP is shown in Table 1.

The 10-month average electricity consumption for the electronic marquee installed with the KIP was (B1) kWh at peak hours and (B2) kWh at non-peak hours. We calculated the peak hour electricity saving ratio SR1 (including electricity consumption for the KIP system) using a calculation formula of (1.25-B1)/1.25, and the non-peak hour electricity saving ratio SR2 (including electricity consumption for the KIP system) using a calculation formula of (1.25-B2)/1.25. The energy-savings potential of the KIP system for the campus marquee was assessed by averaging the SR1 and SR2 electricity saving ratios from the two periods.

Results

Measurements taken on May 4, 2012, indicated that the one-hour electricity consumption rate for the continuously activated electronic marquee (including the accompanying laptop) was 1.25 kWh. After the installation of the KIP system, the electricity consumption rates of peak and non-peak hour periods for 10 continuous school months (between February 2012, and January 2013, are shown in Table 2.

The average peak hour electricity consumption rate was 1.09 kWh, the average

Table 1. Comparison Design on Electricity-Saving Effects of KIP System

Time / Electricity Consumption Category	Peak Hours 6:30-7:30	Non-peak Hours 9:00-10:00
One hour of electricity consumption for the electronic marquee (including a laptop)	1.25 kWh (A)	1.25 kWh (A)
One hour average electricity consumption for the electronic marquee with KIP installed (10 month average)	1.09 kWh (B1)	0.85 kWh (B2)
Electricity saving ratio after KIP installation	SR1= (A-B1) / A	SR2 = (A-B2) / A
Average electricity saving ratio after KIP installation	(SR1+SR2) / 2	

Table 2. The Average and Difference of Electricity Consumption Rates for Two Periods of Electronic Marquee with KIP, or Before and After KIP System Installed

Testing Month \ Time	Peak Hours 6:30-7:30	Non-peak Hours 9:00-10:00	Average Electricity Consumption (kWh)
2012/2	1.14	0.83	0.99
2012/3	1.03	0.86	0.95
2012/4	1.16	0.91	1.04
2012/5	1.02	0.72	0.87
2012/6	1.17	0.88	1.03
2012/9	1.08	0.95	1.02
2012/10	1.02	0.74	0.88
2012/11	1.15	0.97	1.06
2012/12	1.06	0.86	0.96
2013/1	1.04	0.75	0.90
Mean (10-month)	1.09	0.85	0.97
SD (10-month)	0.06	0.09	0.07

Note: 1. Peak Hours vs. Non-peak Hours, ** $p = .000$ ($t = 11.77$, $\alpha = .01$, $df = 9$, $SD = .065$); 2. Before vs. after KIP system installed, ** $p = .000$ ($t = 12.81$, $\alpha = .01$, $df = 9$, $SD = .069$)

non-peak hour electricity consumption rate was 0.85 kWh, and the average electricity consumption rate for peak and non-peak hours was 0.97 kWh. Based on above results, a paired t-test analysis was conducted and found: 1). the difference between peak hour and non-peak hour of Electronic Marquee with KIP was statistically significant ($t = 11.77$, $\alpha = .01$, ** $p = .000$); 2). The use of before and after Electronic Marquee with KIP system also showed a statistically significant difference ($t = 12.81$, $\alpha = .01$, ** $p = .000$). As shown in Table 2, the electricity-consumption rate after the KIP system installation was significantly lower than the electricity consumption rate prior to its installation when the marquee was left on continuously.

Table 3 shows that the one-hour electricity consumption rate for the original electronic marquee system was 1.25kWh. After the installation of the KIP system, the electronic marquee was activated only during human presence, and the average peak hour electricity-consumption rate was 1.09 kWh, providing an average electricity savings rate of 12.8%; the average non-peak hour electricity consumption rate was 0.85 kWh, providing an average electricity-savings rate of 32.0%; the average hourly electricity-consumption rate was 0.97 kWh, providing an average electricity-savings rate of 22.4%.

The above-mentioned results indicate that the KIP system can significantly reduce the electricity consumption of the electronic marquee. Therefore, we suggest that the KIP system can help to achieve the potential for energy savings for an electronic marquee.

Discussion

The intelligent building automation technologies were expected to grow 8.20% during 2010-2015, and there is also expected to be an increase in personalized control of lighting, temperature, ventilation, and other aspects of the interior environment to enhance the productivity of knowledge workers (MarketsandMarkets, 2011). When the issue of saving energy is concerned, electronic devices and facilities, such as lights, air conditioning units, and electronic marquees should only be active during human presence. However, because these devices are not equipped with human-detection devices,

Table 3. The Energy-Saving Effects of the KIP System on the Electronic Marquee

Electricity Consumption Category \ Time	Peak Hour 6:30-7:30	Non-peak Hour 9:00-10:00
One hour of electricity consumption for the electronic marquee (including the used for marquee titles)	1.25 kWh	1.25 kWh
One hour of average electricity consumption for the electronic marquee after KIP installation (10 month average)	1.09 kWh	0.85 kWh
Electricity saving ratio after KIP installation	12.8%	32.0%
Average electricity saving ratio after KIP installation	22.4%	

they are often active when no one is present, and therefore result in an unnecessary waste of energy. Therefore, the KIP system can be expanded to use with other electrical devices that should only be active when humans are present. Taiwan's school system has approximately 200 school days annually. If we multiply 200 school days by 24 hours a day (The marquee is generally on 24 hours per day in Taiwan's schools) and approximately 0.28 kWh of electricity savings per hour (1.25 – 0.97) and thereafter multiply this number by the basic electricity fee of at least NTD $3.00 per 1 kWh, it comes out that the KIP installed electronic marquee will save approximately NTD $4032 for a school year, or USD $137 The calculation formula is as follows:

$$(200 \text{ days} \times 24 \text{ hr} \times 0.28 \text{ kWh} \times \text{NT\$ } 3) \div \text{Exchange rate } 29.5 \fallingdotseq \text{US\$ } 137$$

$$(\text{Kinect US\$ } 220 + \text{IP Power US\$ } 150) \div \text{US\$ } 137 \fallingdotseq 2.7 \text{ Semester Years}$$

The KIP system can save the school at least USD $137 in electricity fees for a school year, excluding non-school days. Considering the KIP system investment costs of Kinect at approximately USD $220 and IP Power at approximately USD $150, it is estimated that the investment costs for the KIP system can be recovered in approximately 2.7 school years. A study by Hittinger, Mullins, and Azevedo (2012) indicated that the U.S. electricity consumption for video games has continually increased and it would increase by 50% between 2007 and 2010. Such an increase in electricity consumption is primarily caused by users' habit of not turning off gaming consoles when they stopped playing. The KIP system developed by this study is ideal to resolve this problem, and we suggest that the gaming industry could add an automatic shutdown design. As long as the users plug the gaming console into the KIP system, the console power source can automatically be activated or deactivated, depending on human presence in the vicinity of the game console.

According to the test result of this study, we also find that the amount of electricity saved by the KIP system is affected by two factors: the basic electricity- consumption rate of the electronic equipment and the amount of human presence. Regarding the basic electricity-consumption rate factor, the installation of the KIP system can save 22.4% in electricity consumption, but because the electricity consumption rate (in kW) for air conditioners is greater than that of electronic marquees, the KIP system can save more electricity (in kW) for air conditioners than it can for electronic marquees. In addition, in terms of human presence, if an electronic marquee is installed at a smaller school, it would have less human presence because of a small number of students; thus, the energy-savings potential will be greater compared to an electronic marquee installed at a larger school.

Based on the above test result and evaluation, we suggest that it is feasible to apply the KIP system in various building spaces and environments, such as school classrooms or libraries, automatic lighting devices, televisions, air conditioners, or energy-saving design for building security-monitoring systems.

Conclusions

Electronic marquees generally stay on and waste energy, even when nobody walks past them or is present to read them. In this study, the KIP system was installed to an electronic marquee system and used EZ-HD electricity monitoring software to test whether the KIP system would have the potential to save energy. We measured the electricity consumption rates at the case study school for 10 continuous months. It was found that the electronic marquee system in its original continuously active state consumed (including the laptop that runs the marquee title software) 1.25 kWh of electricity per hour, and that the average hourly electricity consumption rate for the marquee system with the KIP system installed was 0.97 kWh. The above result showed an average electricity savings rate of 22.4%, and indicated that the KIP system would help to reduce the electricity consumption of the electronic marquee.

Compared to the IR sensor parts used to automate, activate, and deactivate electronic device power sources in the past, we find that the advantages of the KIP system include: 1). It can detect/distinguish human presence and so it will not activate power sources when animals (e.g., cats and dogs) or other moving objects pass by; 2). It has a wider detection range and so it can be reconfigured according to the individual needs when energy saving is concerned. The KIP system provides users with an avenue to save electricity, so we suggest that it is feasible to apply the KIP system in various building spaces and environments, such as school classrooms or libraries, automatic lighting devices, televisions, air conditioners, or energy-savings building design.

Wen-Fu Pan is an Associate Professor in the Department of Educational Administration and Management at the National Dong Hwa Univeristy, Haulien, Taiwan

Shih-Chun Tu is an Assistant Professor in the Department of Computer Simulation and Design, Shih Chien University, Kaohsiung, Taiwan

Mei-Ying Chien is an Associate Professor in the Department of Educational Administration and Management at the National Dong Hwa Univeristy, Haulien, Taiwan

Ya-Moo Zhang is a teacher at Sui-Yuan Elementary School, Haulien, Taiwan

Ali, A. H. H., & Morsy, M. G. (2010). Energy efficiency and indoor thermal perception: A comparative study between radiant panel and portable convective heaters. *Energy Efficiency, 3*(4), 283-301. doi: 10.1007/s12053-010-9077-3

Aviosys International Inc. (2011). *Main features of IP Power* 9258. Retrieved from http://www.aviosys.com/ipenergy.html.

Business Wire (Aug 31, 2011). *Research and markets: Worldwide smart meter revenue to surpass US$12 billion in 2016, ZigBee the early technology leader*. Retrieved from http://www.researchandmarkets.com/research/266c1e/getting_smart_on_w.

Darghouth, N. R., Barbose, G., & Wiser, R. (2011). The impact of rate design and net metering on the bill savings from distributed PV for residential customers in California. *Energy Policy, 39*(9), 5243-5295.

Egan, D. (2005). The emergence of ZigBee in building automation and industrial control. *Computing & Control Engineering Journal, 16*(2), 14-19.

Ember Corporation (2010). Ember emerges as a European Zigbee energy house. *Networks Update, 22*(10), 6-8.

Harvey, L. D. D. (2009). Reducing energy use in the buildings sector: Measures, costs, and examples. *Energy Efficiency, 2*(2), 139-163.

Hill, A. (2012, October 21). *What is an infrared sensor?* Retrieved from http://www.wisegeek.com/what-is-an-infrared-sensor.htm.

Hittinger, E., Mullins, K. A., & Azevedo, I. L. (2012). Electricity consumption and energy savings potential of video game consoles in the United States. *Energy Efficiency*, doi: 10.1007/s12053-012-9152-z

Hu, Y., Jiang, Y., & Zhang, C. (2008). Energy saving control device based on double element pyroelectric infrared sensor. In proceeding of 2008 *Control Conference* (pp. 275-279). July 16-18, 2008, Kunming, China.

Joseph Technology (2011). *Wireless energy meter: EZ-R series*. Retrieved from http://www.joseph-tech.com.tw/products/products_ez_r.htm.

Kumaragurubaran, V. (2011). *Sensing, actuating and processing in the built environment: A beginners guide to physical computing tools*. Retrieved from http://quicksilver.be.washington.edu/courses/arch498cre/2.Readings/1.PDFs/Beginners%20Guide%20to%20Physical%20Computing.pdf.

Ma, Y. (2012). The design and application of intelligent electrical outlet for campus's electricity saving and emission reduction. *Journal of Computers, 7*(7), 1696-1703.

MarketsandMarkets (2011, March). *Global intelligent building automation technologies: Systems services and information Technology market size and forecasts* (2010-2015). Retrieved from http://www.marketsandmarkets.com/Market-Reports/building-technology-346.html.

McCain, D. (2011, June 1). Enabling Zigbee's smart energy 2.0 with advanced wireless modules. *Electronic Component News, 55*, S6-S8.

Moradi, M., Ghaisari, J., Askari, J., & Gorji, M. (2011, May). A new method for detection of a distributed event in wireless sensor networks. In H. S. Zadeh (Chair), *2011 19th Iranian Conference on Electrical Engineering (ICEE)*. Symposium conducted at the meeting of IEEE. Tehran, Iran.

Pan, W.-F., Chien, M.-Y., Liu, C.-C., & Chan, K.-H. (2012). Feasibility analysis of improving the accessibility and security of nano-labs via Kinect. *International Proceedings of Computer Science and Information Technology, 24*, 138-141.

Pan, W.-F., Chien, M.-Y., & Tu, S.-C. (2012, September). The feasibility assessment of using a Kinect-Tablet Integrated System to improve electric wheelchair reversing safety. *Industrial Technology and Management*, *49*, 121-125.

Pan, W.-F., Lin, H.-F., & Wu, M.-Y. (2011, July). Using Kinect to create active-learning situations for nanotechnology labs/classrooms. In Chin-Chen Chang (Ed.), *2011 3rd International Conference on Education Technology and Computer* (pp. 54-56). Singapore: IACSIT press.

Pan, W.-F., Tu, S.-C., & Chien, M.-Y. (2012). Feasibility analysis of improving on-campus learning paths via a depth sensor. *Interactive Learning Environments, iFirst*, 1-24. doi: 10.1080/10494820.2012.682585

Rothe, S. B., & Girhepunje, V. G. (2012). Design and implementation of real time wireless biomedical system based on ZigBee-GSM interactive module. *International Journal of Engineering Research and Applications, 2*(5), 1894-1899.

Sadineni, S. B., Madala, S., & Boehm, R. F. (2011). Passive building energy savings: A review of building envelope components. *Renewable & Sustainable Energy Reviews, 15*(8), 3617-3631.

Shehabi, A., Masanet, E., Price, H., Horvath, A., & Nazaroff, W. W. (2011). Data center design and location: Consequences for electricity use and greenhouse-gas emissions. *Building & Environment, 46*(5), 990-998.

Sober, J. (2011. October 6). *Home energy management*. Retrieved from http://www.acadtest.com/news/131795818315593200-home_energy_management.html.

Yamtraipat, N., Khedari, J., Hirunlabh, J., & Kunchornrat, J. (2006). Assessment of Thailand indoor set-point impact on energy consumption and environment. *Energy Policy, 34*(7), 765-770.

ZigBee Alliance (2012). *About: Our members*. Retrieved from http://www.zigbee.org/About/OurMembers.aspx.

The Cognitive Processes and Strategies of an Expert and Novice in the Design of a Wireless Radio Frequency Network

By Matthew Lammi and Timothy Thornton

ABSTRACT

The purpose of this study was to understand the cognitive processes and procedures employed by an expert and a novice engineer in a realistic radio frequency (RF) systems engineering design challenge by using verbal protocol analysis (VPA). The engineering design challenge encompassed engineering, political, and social constraints. The audio data were then transcribed, segmented, and coded for analysis. The processes and strategies of the expert and novice were juxtaposed for analysis. The expert and novice shared some similarities in their cognitive processes and strategies. However, the expert's domain knowledge and experience was vastly distinct from that of the novice.

Keywords: Engineering design, Systems Design, Design Cognition, Expert- Novice engineer, Engineering and technology education

Introduction

Technological and engineering literacy are critical components of a prosperous society. One dimension of both technological and engineering literacy can be defined as ". . . a way of thinking and acting" (Pearson & Young, 2002, p. 3). Cognitive science addresses ways of thinking as a window to the human mind, shedding light on thought processes and how the mind is structured (Adams, Turns, & Atman, 2003). Because technology and engineering are better understood within the domain of cognition, the further the promulgation of a technologically and engineering literate society. One way to study cognitive processes and strategies is through verbal protocol analysis (Kruger & Cross, 2001).

Engineering is a topic of interest not only limited to the postsecondary training of engineers, but it is also found in the K-12 settings as an educational discipline rich in innovation, problem solving, and higher order thinking skills (Brophy, Klein, Portsmore, & Rogers, 2008). Although engineering literacy is becoming a part of the American educational landscape, there is much to be understood about what engineering literacy is and how to teach it to nonengineering K-12 students. One aspect of engineering literacy is putting engineering habits into thought and action. To better understand these habits, one can employ an expert/novice perspective, where the expert is an engineer and the novice is the presumed student. This perspective describes the point where a student currently is (novice) and where that student could be (expert). The aim of this study was to further the knowledge base of engineering cognition by describing the cognitive processes and strategies of both an expert and a novice in the design of a wireless communications system.

The research questions for this study were:

- What cognitive processes and strategies are used by an expert and a novice in engineering design?
- How do the expert's and the novice's cognitive processes and strategies compare?

Research Literature

This study is based on the foundation of cognitive science as it pertains to engineering and technology education (Brown, 2001). Engineers and technologists are given the task to solve problems, both in the classroom and in practice. Design is a category within problem solving that is cognitively intensive (Jonassen, 2000). Cognition is more than simply to know something; it stems from the Latin word cognoscere, meaning to become acquainted with (Cognition, 2013). To become intimately acquainted with a particular field of practice, one has to acquire thorough knowledge and develop intricate associations. This knowledge and these associations are represented in cognitive science by complex arrays of networks known as schema (Brown, 2001). One of the goals of engineering and technology education is to expose the student to, and hopefully move the student closer to, the skills and thinking of an expert in the field. By observing and analyzing cognition, research may reveal further insights into how experts and novices approach and strategize engineering and technology design. These insights might then aid in engineering curriculum and practices.

Engineering Design

The pervading concept of design is interwoven throughout engineering processes and culture (Burghardt & Hacker, 2004). Design is a nebulous process that may be perceived from either a scientific or an artistic viewpoint (Cross, 2001). Design is dynamic and iterative; therefore, it is not easily represented by simple linear models (Mawson, 2003). Design typically commences with defining and formulating the problem (Cross, 2004). Formulating the problem includes the gathering of pertinent data, delineating the overall goal, and creating an initial plan or "next steps."

Engineering design is more than the manipulation of numbers and the solving of scientific equations. The processes employed in engineering design encompass a broad variety of topics and fields of study. Bucciarelli (1988), an ethnographer, described engineering as a social process. The National Academy of Engineering (2004, 2005) clearly stated that engineering education was lacking if it did not include the global perspective in engineering design such as social, political, and environmental issues. The global perspective in engineering is part of systems engineering. Systems engineering involves viewing design from the whole-systems level rather than from an isolated modular perspective.

Jonassen (2000) placed design in its own problem type in his taxonomy of problem solving. Design is not only listed as complex and ill-structured, but it also requires higher order problem-solving skills. Engineering design typically entails resolving the designer's goal and the criteria set forth by clients or other external parties (Cross, 2002). Very often the external criteria are associated with resources, such as capital or time. Jonassen and Tessmer (1996) further asserted that as a problem type, design skills are influenced by domain knowledge, cognitive skills, and affective traits. This has been supported by Ericsson (2001), who stated that focus and commitment are also factors in expertise.

Because design is an important aspect of both engineering and technology, it has been the focus of numerous studies involving engineering cognition (Atman & Bursic, 1998; Atman, Kilgore, & McKenna, 2008; Cross, 2002; Ericsson & Simon, 1993; Jonassen, 2000; Lammi & Branoff, 2012). These studies used verbal protocol analysis (VPA), or a variation of this analysis, as a major component in gathering data. If VPA is used, the participants verbalize their thoughts out loud while engaged in a task or while solving problems. The participants typically engage in a hypothetical engineering problem or challenge in order to stimulate increased cognitive activity. The VPA is performed in a room where there are few distractions to help the participant maintain mental focus. The participant is also accompanied by a researcher or assistant who records the verbalization with either an audio or video recorder. Although Hayes (1989) conceded that verbal protocols are typically incomplete, he also claimed that under controlled conditions there is no evidence that verbal protocols distort or interfere with a participant's thinking while that participant is engaged in a task.

Expert versus Novice

Students and experts vary according to their ability in engineering design. These differences of engineering design cognition are often analyzed against the expert and novice continuum (Atman et al., 2008; Cross, 2002; Lawson & Dorst, 2005). The novice is limited by experience and knowledge, resulting in a partial and simple schema. The expert has a vast depth of experience and focused practice within a domain, resulting in deep and rich schemata (Cross, 2004). However, experience and knowledge alone do not ensure expertise. The manner in which the experience and knowledge is ordered and interrelated has a great impact on expertise.

An expert is able to recognize large amounts of information, or chunks (Egan & Schwartz, 1979). From these chunks, an expert can recognize what information is relevant to the issue at hand. This enables the expert to quickly and efficiently wade through data and facts with fast retrieval from her/his memory or schemata. This process may be compared to the routing of data packets in a computer network.

The switches are constantly "learning" new and efficient pathways to connect data from one end user to another. The more complete and expanse the connections, the quicker the routing of the data packets. As more equipment and nodes are added to the network, the possibility of a more efficient pathway is introduced. It is evident that adding more nodes to the network alone does not increase efficiency. Rather, it is the deliberate and continual attempts to reroute by the switching equipment that increases efficiency. Hence, when new information or experience is added to the human mind, it is only useful if a purposeful association is made. This deliberate and focused effort was explained by Ericsson (2001) as the primary difference between experts and those who are only proficient in their domains. However, as the solution space evolves and elucidates further constraints, the expert returns to and references, or redefines, the problem space iteratively until the design is implemented, tested, and concluded. These attributes can be combined together to highlight the "know how" that is often demonstrated by an expert. The literature in engineering design cognition has primarily employed verbal protocols analyzed against the expert-novice continuum. Although systems have garnered attention in recent literature (Davis & Sumara, 2006), research regarding cognition in systems engineering design is limited.

Methods

The purpose of this investigation was to understand and compare both an expert's and a novice's cognitive processes and strategies while they are engaged in the design of a systems engineering challenge. There were two participants in this study, an expert and a novice in wireless systems design. A small number of participants was chosen to allow an in-depth analysis of the data. Each of the VPA generated hundreds of data points that were coded and analyzed. The design challenge given to the participants was a hypothetical radio frequency (RF) systems design. The hypothetical setting was chosen to help capture the participants' thinking within the bounds of a VPA.

An RF network is a system of cellular phone towers and accompanying equipment distributed throughout an area to provide cellular phone service. RF systems designs encompass engineering, political, and social variables and constraints. The design challenge was a simulated open-ended RF engineering problem.

VPA was used in this study to gather participants' cognitive strategies and processes as they performed their tasks. Both were invited to share everything they were thinking during the design challenge. To increase trustworthiness and minimize leading questions during the VPA, both participants were only prodded to verbalize if there was at least a five-second pause in sharing their thoughts. As both were encouraged to share all of their thoughts, the resulting transcription was not always coherent or grammatically correct. The VPA was followed immediately by an interview to clarify ambiguities that emerged during the challenge. Additionally, the researcher annotated observations during the challenge, and a design artifact was collected and analyzed. Following the design activity, the audio data were transcribed, categorized, and coded for analysis (Glesne, 2006).

Participants

The sample for this study included two participants drawn from the opposite ends of the expertise continuum in the domain of RF engineering system design. As such, they were selected regarding their skill set within RF engineering system design. Although RF systems engineering is not typically taught at U.S. universities, the coursework in electrical or electronic engineering generally serves as a basic foundation. Additionally, an RF engineer must also have a solid understanding of wave propagation theory in addition to digital communications. To gain proficiency in RF systems design, the engineer must grasp the societal and political impacts while working collaboratively across a wide array of teams (ranging from construction crews to executive management). Expertise in RF engineering is generally obtained through extensive practice in industry because of the frequent complex human interactions that must be balanced with sound engineering design.

An expert RF engineer is not only the most senior engineer among peers, but this person often consults other engineers nationally and internationally. Even within the domain of RF engineering, there are subdomains where one may achieve further expertise: design, optimization, and spectrum allocation. The expert for this study, Robert (pseudonym), had over thirteen years of RF systems engineering design experience working for a major cellular provider in various positions (ranging from manager to internal consultant). This expert received a bachelor's degree in electrical engineering and continued his education through self-learning and corporate training.

The other participant, Gary, was a novice and at the other end of the spectrum of RF systems engineering. He was a professor in electronic engineering technology and had taught electronics at the postsecondary level for more than 35 years. Although this participant was a novice in RF systems engineering design, he had a breadth of skills in pedagogy and undergraduate electronics. He was chosen as the novice because of his background in electrical theory and practical experience with electromagnetic wave propagation; however, he did not have any specific training in RF systems engineering design.

Design Challenge

The participants were asked to design a new RF network in an isolated college town as if they were engineering design consultants. This challenge took place in a small office; only the participant and a researcher were present. Prior to the VPA, both participants were invited to perform a warm-up activity to prepare them to think out loud. In this warm-up activity, both participants gave a virtual tour of their homes. The participants described in detail the interior of their homes, including the windows, wall colors, and type of wood of the cabinets.

Immediately after the warm-up activity, the participants were given a three- dimensional aerial map overlaid with major and minor transportation thoroughfares to aid in the design, as seen in Figure 1. Each participant was invited to place potential cellular towers on this map. Constraints were placed in the design challenge to create a realistic ill-defined scenario. The constraints were to limit capital expenditures and abide by the zoning to not exceed 60-foot towers, and design cell sites to be hidden or

Figure 1. 3D Aerial Map Used During the Design Challenge

stealth. Additionally, both were made aware of high cellular traffic venues, such as a university with 18,000 students and a fictitious annual wakeboarding event that would draw 10,000 individuals.

A follow-up interview was also conducted immediately following the design challenge. The interview questions included the following: why each participant chose varying cellular sites, why certain methods and strategies were employed, and what they were thinking during prolonged pauses. Additionally, the 3-D map served as an artifact for triangulation with the participant's verbalization and interview responses.

Data Collection and Analysis

The audio from the design challenge was transcribed into a word processor. The transcription was broken into units or segments. The segments consisted of a sentence, unless a separate thought or idea surfaced necessitating further segmenting. The segments were coded into distinct mental processes used in engineering. Various methods have been used in coding verbal protocols (Atman & Bursic, 1998; Kruger & Cross, 2001), in contrast, the coding for this study was done from the perspective of the researcher as themes emerged. Although there are various engineering coding schemes, for purposes of this research, a thematic approach was employed to discover any salient themes that emerged. Existing, well-defined coding schemes could potentially limit the outcomes and findings. Furthermore, RF systems engineering is a phenomena that has not been widely researched, especially through VPA.

The Verbal Protocol Analysis

To help the participants relax and have their minds free from distraction the VPAs took place on Friday afternoons when work was slow. To further minimize distractions, the VPAs took place in a quiet and secluded fluorescent-lit room with little decorations. Each participant and the researcher sat at a huge wood laminate table at the middle of the room while they shared their thoughts on solving the design challenge.

Results

Because both participants had multiple years of experience at the systems level in electronics, they both initially utilized a top-down approach in their design. Such an approach begins with the big picture and then breaks the design into its components. Robert, the expert, initially stated, "Is this for the whole area, or is it . . . ?" Not only did Robert commence with this method, he also designed the system to interact with potential existing systems. Both participants also used an iterative process evaluating and visualizing their design against the various constraints. However, Robert was able to more thoroughly analyze and balance the constraints, such as zoning and leasing. Robert quickly noted, "The zoning limitations listed here as stealth design – hmm. Okay, now these are competing requirements: limiting capital expenditures and stealth."

Both the expert and the novice frequently returned to foundational principles for predictions and site locations. Gary, the novice, was fully aware of his limitations and stated repeatedly that he did not have the experience and knowledge to make an accurate design. At one point Gary stated, "I have a lot of questions, but I am not sure." Conversely, the expert was able to make mental predictions or visualizations of the design and relied heavily on experiential and episodic memory. Robert discussed his experience with universities saying, "The university populations historically have a really high penetration rate for mobiles." Although both participants recognized high cellular traffic areas, Robert knew how to quantify and optimize the design. Robert stated, "We are around 80-85% penetration rate now. So, obviously we are going to want to [get] very good coverage along the interstates and highways to support where people frequently use their mobile phones in travel." One possible explanation for this was that the novice did not recognize the particularly high cellular phone traffic implied by a university or a wakeboarding competition.

Robert's, as an expert, design strategy revealed differences from that of Gary's, as a novice. Robert approached the design from a personal viewpoint, drawing heavily from previous experiences and precedents. The expert made frequent references to his experiences, particularly with respect to capital expenditures. Robert commented on the zoning requirements impacting the capital funds, "Because you have lower antenna heights required by the stealth design, you know there is an elevated cost to build sites." Although the participants were given the same tasks, Robert set about the design from the context and point of view of a consultant. He felt that he had to produce a design that was feasible, both financially and with respect to RF engineering. Robert not only produced design, but he also made statements about how it would be zoned, leased, and constructed. Context is an important factor in problem solving, and it was evident in Robert's responses. From the expert's perspective, Robert spent a considerable amount time managing and justifying his design.

One of the most striking contrasts between the participants was the attention Robert gave to the optimization of capital expenditures. It is noteworthy how quickly he recognized the two rival requirements of reduced costs and stringent zoning restrictions commonly known as stealth. This same theme pervaded his entire design process. Even though Robert made 16 references about costs, Gary mentioned costs only 3 times. Additionally, Robert's design proposed only 7 sites (versus 15 for Gary), substantially reducing the cost of the proposed design. Although Gary recognized financial costs in his design, Robert framed nearly every design aspect within the context of costs. This is not surprising since Gary's career is in academe, and Robert's was exclusively in industry, daily working within budgets.

Another striking difference between the expert and the novice was the amount of knowledge in the domain. Figure 2 is a pair of concept maps that reveal the disparity in knowledge differences. The researchers created the concept maps to visually highlight the differences reported between the responses of the novice and expert. Gary did not have the breadth and depth of knowledge that Robert did. Gary also did not allude to or even mention spectrum considerations.

However, the novice did have a working knowledge of radio frequency electromagnetic wave propagation. Gary did mention zoning, leasing, and capacity, but this could partially be accounted for by the design brief. Although not shown on the concept maps, Robert not only mentioned the different aspects within RF design, he also made many connections and associations between concepts.

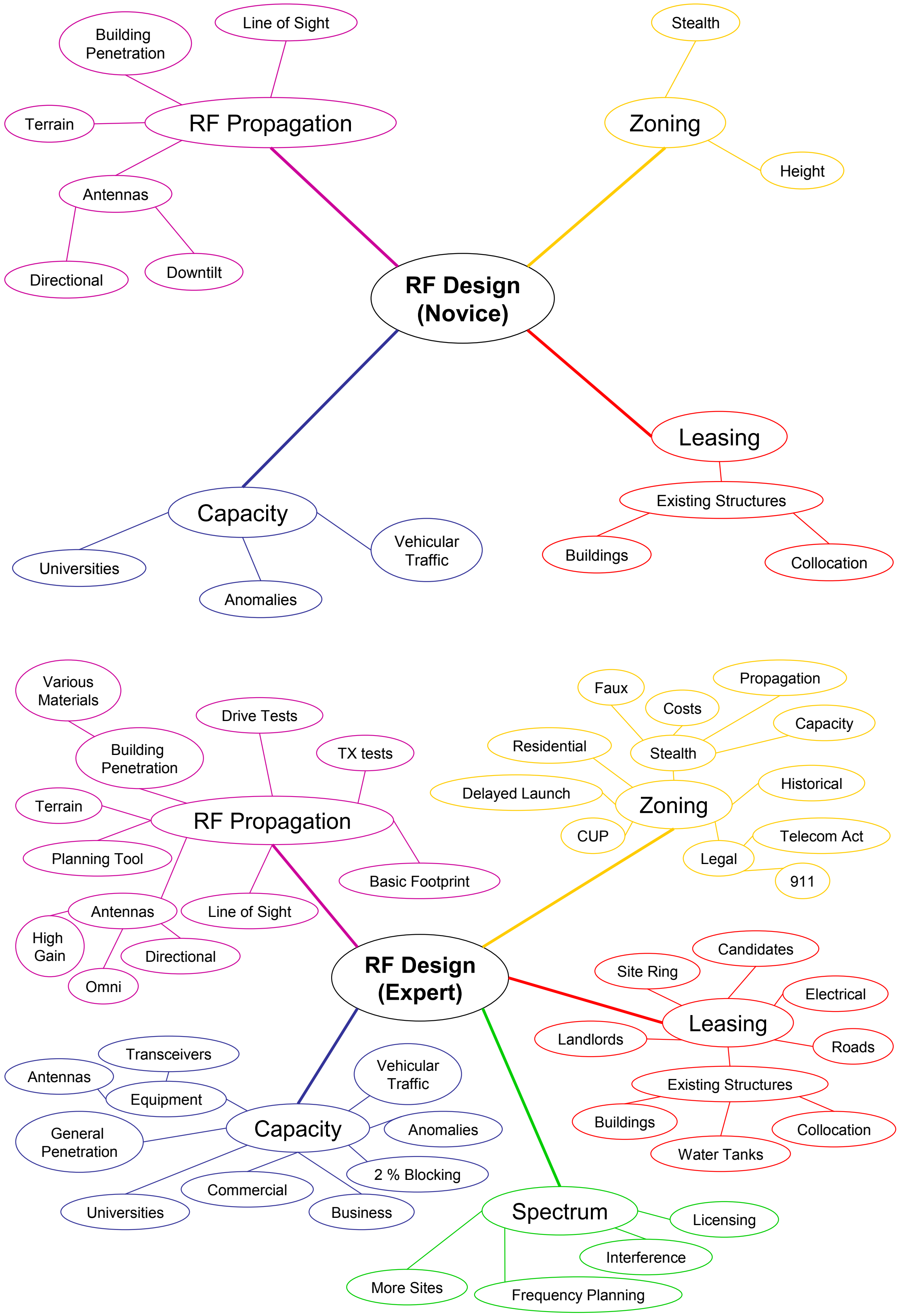
Robert demonstrated the idea of satisficing, or the yielding of an ideal design for one that is only satisfactory. This was expressed as he managed limited capital and accounted for stealth zoning. Robert also made use of techniques unique to his trade, or gambits, to help overcome the stealth requirements. The expert employed water towers, rooftops, and stadium lights as economical alternatives to other costly stealth solutions. Gary was prompted for further analysis and design but he replied, "Experience would probably tell a person more information whether [the system design] is enough or . . . not." Gary was aware that he lacked the relevant experience and domain-specific knowledge to elaborate on his design.

Discussion

From the study we can see how an expert and a novice are alike and how they differ regarding RF engineering system design. The expert exhibited expansive practical knowledge within his domain. The expert also maintained a systems perspective throughout his design by accounting for costs, zoning, and other teams' needs. Furthermore, the expert approached the design challenge from a distinct context. Engineering and technology educators might do well to broadly educate their students to become systems thinkers (National Academy of Engineering, 2005). This systems approach to teaching could include costs, organizational behavior, and political and societal impacts. The design method may be taught, but emphasis should be placed on the idea that there is no universal problem-solving model. Lastly, systems-level engineering could be infused into the curriculum as a top-down approach. This approach emphasizes breadth as well as depth, with the depth being situated in context and not isolated. Presenting the overall concept and then delving into components is an alternative method for reaching varying types of students' learning. This article has presented a few ideas that could be infused to engineering and technology education practice and research that could further increase technological and engineering literacy.

This study included only two participants, one on each end of the expert-novice continuum.

Figure 2. Concept Maps of Gary's (Novice) and Robert's (Expert) RF Designs



Any findings or conclusions were made in light of this limitation. Further research that includes a greater number of participants would be more conclusive. Nonetheless, the results of this study could help be a springboard for other studies and serve as another datum point among other similar studies.

Dr. Matthew Lammi is an Assistant Professor of STEM Education at North Carolina State University, Raleigh. He is a member of the Alpha Pi chapter of Epsilon Pi Tau.

Timothy Thornton is a doctoral candidate within the department of Technology, Design, and Engineering Education at North Carolina State University, Raleigh. He is a member of the Alpha Pi chapter of Epsilon Pi Tau.

References

Adams, R. S., Turns, J., & Atman, C. J. (2003). Educating effective engineering designers: The role of reflective practice. *Design Studies, 24*(3), 275-294.

Atman, C. J., & Bursic, K. M. (1998). Verbal protocol analysis as a method to document engineering student design processes. *Journal of Engineering Education, 87*(2), 121-132.

Atman, C. J., Kilgore, D., & McKenna, A. (2008). Characterizing design learning: A mixed-methods s tudy of engineering designers' use of language. *Journal of Engineering Education, 97*(2), 309-326.

Brophy, S., Klein, S., Portsmore, M., & Rogers, C. (2008). Advancing engineering education in P-12 classrooms. *Journal of Engineering Education, 97*(3), 369-387.

Brown, D. (2001). Cognitive science concepts and technology teacher education. *Journal of Technology Studies, 27*(1), 33-42.

Bucciarelli, L. L. (1988). An ethnographic perspective on engineering design. *Design Studies, 9*(3), 159-168.

Burghardt, M. D., & Hacker, M. (2004). Informed design: A contemporary approach to design pedagogy as the core process of technology education. *The Technology Teacher, 64*(1), 6-8.

Cognition. In Merriam-Webster's online dictionary. (2013). Retrieved from http://www.merriam-webster.com/dictionary/cognition

Cross, N. (2001). Designerly ways of knowing: Design discipline versus design science. *Design Issues, 17*(3), 49-55. doi:10.1162/074793601750357196

Cross, N. (2002). Creative cognition in design: Processes of exceptional designers. In T. Hewett & T. Kavanagh (Eds.), *Creativity and cognition* (pp. 6-12). New York: ACM Press.

Cross, N. (2004). Expertise in design: An overview. *Design Studies, 25*(5), 427-441.

Davis, B., & Sumara, D. (2006). Complexity and education: Inquiries into learning, teaching, and research. Mahwah, NJ: Erlbaum.

Egan, D., E., & Schwartz, B., J. (1979). Chunking in recall of symbolic drawings. *Memory & Cognition, 7*(2), 149-158.

Ericsson, K. A. (2001). Attaining excellence through deliberate practice: Insights from the study of expert performance. In M. Ferrari (Ed.), *The pursuit of excellence through education* (pp. 4-37). Hillsdale, NJ: Erlbaum.

Ericsson, K. A., & Simon, H. A. (1993). Protocol analysis: *Verbal reports as data*. Cambridge, MA: MIT Press.

Glesne, C. (2006). *Becoming qualitative researchers: An introduction* (3rd ed.). Boston, MA: Pearson, Allyn and Bacon.

Hayes, J. R. (1989). *The complete problem solver* (2nd ed.). Hillsdale, NJ: Erlbaum.

Jonassen, D. (2000). Toward a design theory of problem solving. *Educational Technology Research and Development, 48*(4), 63-85.

Jonassen, D., & Tessmer, M. (1996). An outcomes-based taxonomy for instructional systems design, evaluation, and research. *Training Research Journal, 2*, 11-46.

Kruger, C., & Cross, N. (2001). Modeling cognitive strategies in creative design. In J. S. Gero & M. L. Maher (Eds.), *Computational and cognitive models of creative design V* (pp. 205-226). Sydney: Key Centre of Design, University of Sydney.

Lammi, M., & Branoff, T. (2012). *High school students' habits of mind and action in engineering design*. Paper presented at the ASEE Annual Conference, San Antonio, TX.

Lawson, B., & Dorst, K. (2005). Acquiring design expertise: A first attempt at a model. In J. S. Gero & M. L. Maher (Eds.), *Computational and cognitive models of creative design VI* (pp. 213-229). Sydney, Australia: University of Sydney, Key Centre of Design Computing and Cognition.

Mawson, B. (2003). Beyond 'The design process': An alternative pedagogy for technology education. *International Journal of Technology and Design Education, 13*(2), 117-128.

National Academy of Engineering. (2004). *The engineer of 2020: Visions of engineering in the new century*. Washington, DC: The National Academies Press.

National Academy of Engineering. (2005). *Educating the engineer of 2020: Adapting engineering education to the new century*. Washington, DC: The National Academies Press.

Pearson, G., & Young, A. T. (Eds.). (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington, DC: The National Academies Press.

The Role of Innovation Education in Student Learning, Economic Development, and University Engagement

By Christy Bozic and Duane Dunlap

Abstract

A model is suggested for the inclusion of innovation education in engineering technology academic programming to enhance student learning, drive business growth, and advance university engagement. Specifically, academic programs that include experiential educational opportunities focused on innovation theory coupled with business and industry partnerships provide a framework for engineering technology students to apply their knowledge benefiting the students, companies, and the regions we serve. These strategic partnerships provide faculty and students with the opportunity to drive economic development through basic research, applied research, workforce education, training, technology transfer, and technical assistance. Successful university-industry collaborations are examined in this paper. Additional research is needed to develop collaboration impact measurements, learning outcomes assessments, and appropriate metrics to quantitatively measure successful collaboration activities.

Key words: Innovation Education, Engineering Technology, Technology Education, Economic Development, University Engagement, Curriculum Development.

Introduction

The need for the integration of innovation curriculum in colleges and universities has been a topic of ongoing discussion at the national level. The Council on Competitiveness, a national organization of CEOs, university presidents, and labor leaders working to ensure American prosperity, held a national innovation initiative summit in 2005 that convened researchers, educators, and business leaders to discuss innovation. From this initiative, the council published a report titled, Innovate America: Thriving in a World of Challenge and Change (Council on Competitiveness, 2005). The report details a national innovation agenda focusing on talent, investment, and infrastructure that allows for innovation growth. The Council on Competitiveness suggests that talent, and more specifically, engineering talent, is our nation's essential innovation asset, although the number of engineers entering the field are not replacing retirees in sufficient numbers (National Science Foundation, 2012). While filling this engineering gap, universities have the opportunity to incorporate relevant innovation-based curricula that are reflective of ill-structured, real-world scenarios for applied engineering and technology students. Colleges and universities are best suited to respond to the challenge of fostering the skills of creative thinking and innovation in their engineering and technology students through engaging and relevant curricula (Sandeen & Hutchinson, 2010).

A university's contribution to local economic development has been long studied and well documented. Historically, universities have viewed traditional research and education as major contributors to economic development (Smith, Drabenstott, & Gibson, 1987). Though discovery and knowledge transfer remain essential cornerstones to university engagement missions, there has been increasing emphasis on expanding the role universities play in innovation and competitiveness to create wealth. The Association of Public and Land-grant Universities' Commission on Innovation, Competitiveness and Economic Prosperity (Milliken, 2012) published a summary of suggestions from business and education leaders for areas of engagement. These suggestions include developing and commercializing technology, increasing industrial collaboration, developing economic policy, developing STEM talent, fostering entrepreneurship, and creating deeper partnerships within P-16 education. Universities are incorporating these strategies to play a key role in building knowledge-based innovation economies. Higher education leadership teams can accomplish this by placing emphasis on creating an entrepreneurial culture to cultivate a fertile ecosystem to promote new business growth. As a result of this culture shift, these universities tend to attract more creative entrepreneurs who have a penchant for innovation and can discover and commercialize new technologies focusing on business attraction.

According to one research-based, Midwest university's economic development working group, ". . . universities have a huge role in this new economy: helping to support research and innovation. . . build communities that will meet the needs and expectations, and be attractive, to those with the creative mindsets that are essential for fostering innovation and entrepreneurship" (Deason, 2008, p. 4). This university views its role as a crucial link in the "educational supply chain" (Deason, 2008, p. 4) by creating an innovation culture for faculty, students, and partners.

Universities play a key role in economic development by generating and attracting talent. One of the most critical mechanisms of knowledge transfer from publicly funded universities comes from recently employed skilled graduates in industry (Wolfe, 2005). Research intensive universities produce graduates who enter industry with high levels of research training and applied knowledge. While it is often difficult to quantify these benefits, Bramwell and Wolfe (2008) suggested that students represent the key transfer mechanism to channel scientific research from government-funded universities into industry for the broader purpose of economic development. Engineering technology educators have the opportunity to impart technology-creating skills to students while fostering an innovation mindset (Green, Smith, & Warner, 2012). Providing students with opportunities to apply theoretical knowledge to solve real-world problems allows educators to meet the stated educational mission while contributing to an economic engagement mission.

Applied engineering and technology curricula that incorporate topics such as innovation theory or the innovation process have been shown to better prepare engineers for the global economy (Orr & Eisenstein, 1994; Steiner, 1998). Today's global economy requires engineers to assume the lead role in innovation and idea generation. Although innovation and innovation theory are important topics in engineering technology education, they are not typically taught or embedded within engineering curricula. If innovation and entrepreneurship theory are applied, students can learn to solve ill-structured, real-world business and industry problems (Sandeen & Hutchinson, 2010). Even without an innovation curriculum in engineering and technology degree programs, approximately 60 percent of the CEOs in the Fortune 100 companies have engineering or science degrees (President's Council of Advisors on Science and Technology, 2004).

Innovation and Entrepreneurship Education

At the national innovation summit, the Council of Competitiveness defined innovation as the intersection of invention and insight, leading to the creation of social and economic value (Council on Competitiveness, 2005). Additionally, innovation can be defined as "the process by which technological ideas are generated, developed and transformed into new business products, processes and services that are used to make a profit and establish marketplace advantage"(Mogee, 1993, p. 410). Common to these definitions is the concept of the creation or manipulation of a product or process to be used in a new or different way. During a State of the Union address in 2011, President Obama said, "The first step in winning the future is encouraging American innovation. In America, innovation doesn't just change our lives. It is how we make our living." The president emphasized the role of government and universities to drive innovation through discovery, education, and university engagement. "But because it's not always profitable for companies to invest in basic research, throughout our history, our government has provided cutting-edge scientists and inventors with the support that they need" (The White House Office of the Press Secretary, 2011). Additionally, President Obama underscored the need for further investment in university research and development, challenging educators to focus on education initiatives that promote innovative ideas. To meet this need, universities and colleges are partnering with government, business, and industry by offering educational programs that promote innovation education. Even though these academic programs often contain the word innovation in their title, much of the curriculum is focused on subjects that could be encompassed under the umbrella of entrepreneurship. Entrepreneurship and innovation are often combined into a curriculum and treated as the same theory or subject. Innovation and entrepreneurship are really quite different in both theory and practice. Innovation and entrepreneurship can be viewed as a continuum with innovation as an input in the form of invention and/or product and process development. As a consequence or outcome of this innovation, new businesses or existing business growth is recognized as entrepreneurship (Duval-Couetil & Dryrenfurth, 2012). Many of terms used in the definitions of entrepreneurship concentrate on business concepts such as market trends, leadership, and new business ventures. Terms like these are markedly different than the terms previously mentioned in the definition of innovation. Drucker framed the theories of entrepreneurship and innovation as complementary, but with distinct differences. Innovation is described as a function of entrepreneurship, whether in an existing business or a new venture. When describing entrepreneurship, Drucker stated, "The term, then, refers not to an enterprise's size or age but to a certain kind of activity. At the heart of that activity is innovation: the effort to create purposeful, focused change in an enterprise's economic or social potential" (Drucker, 1998, p. 149).

The study of innovation and innovation theory in engineering and technology is essential for understanding new product and process development, effective decision making, strategic marketing, and leadership excellence. The power of innovative ideas can revolutionize companies and spur new markets. A poll of the top 1,500 international CEOs cited innovative creativity as the top leadership trait for their companies (Dyer, Gregersen, & Christensen, 2009). Figure 1 presents the words or phrases CEOs use to describe the top leadership characteristics for today's economic environment (Berman, 2010).

Given the importance of innovation for new business growth, the theory of innovation can and should be taught to technology students. One such example of innovation theory is that of disruptive innovation. A disruptive innovation creates a new market by applying a different set of values, which ultimately (and unexpectedly) overtakes an existing market (Christensen, 1997). The examination of Netflix's role in the video movie rental market provides a simplified case of disruptive innovation. Netflix is a service that allows customers to stream movie content to any web-based device on demand, thus eliminating the need for customers to drive to video rental stores and choose from in-stock movie title options. Using a customer-focused and low-cost business model, Netflix disrupted the traditional business model of competitors such as Blockbuster. Disruptive innovation theory explains how new companies can utilize "relatively simple, convenient, low-cost innovations to create growth and triumph over

Figure 1: Word cloud with top leadership qualities CEOs cited as most important

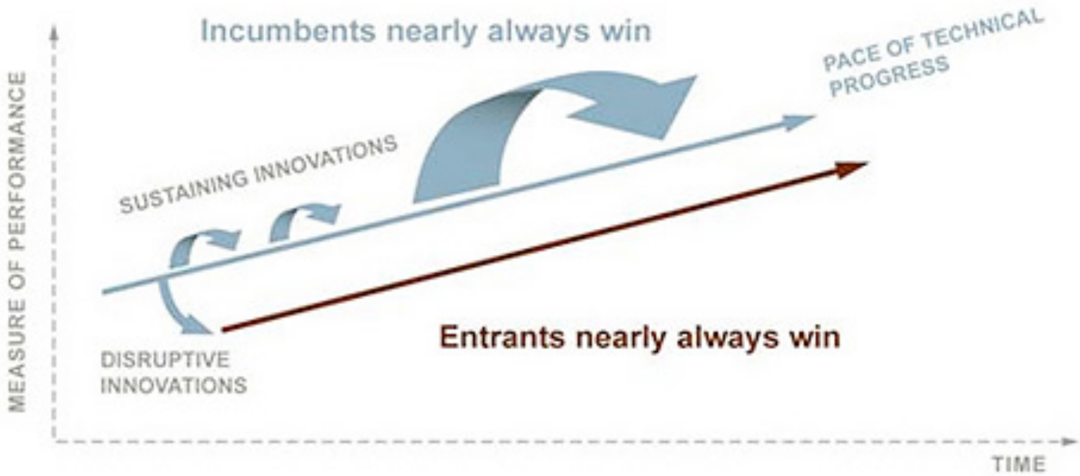


Figure 2: Disruptive innovation model. Reprinted from Clayton Christensen, Disruptive Innovation, by C. Christensen, 2012, Retrieved from www.claytonchristensen.com. Copyright 2012 by Clayton Christensen. Reprinted with permission.

power incumbents" (Christensen, Anthony, & Roth, 2004, p. xv). Additionally, the theory of disruptive innovation suggests that large market leaders or existing companies can maintain market share and market position when an entrant company introduces an innovation that is considered sustaining. A sustaining innovation is one that improves upon existing products or processes (Christensen & Raynor, 2003). When an entrant company introduces a product or service that is disruptive in nature, it changes the entire market because the innovation introduces the new product to an entirely new customer base. Figure 2 provides an illustration of disruptive innovation theory. The lines with arrows illustrate a company's product or process improvement trajectory in a given market. Disruptive innovation theory suggests the incumbent companies in the market will most likely win additional market share on sustaining innovations that marginally improve an existing product as detailed in the top curved arrow. Companies have historically invested in the development of these sustaining innovations charging higher prices to their current customer base with these marginal improvements. It is with these sustaining innovations that companies serve their most sophisticated or demanding customers at the top of any given market to recognize more immediate profits (Christensen, 2012).

By serving top-tier customers, incumbent companies are left open to competition by entrant firms with disruptive innovations to dominate the bottom of the market. These disruptive innovations usually introduce the product family to an entirely new market base who may not be market participants if not for this disruptive product. Innovative disruptions are usually lower in cost, quality, and performance than what the incumbent company produces. Because of the lower cost, slimmer margins, and the perception of inferiority, disruptive innovations are often unattractive to incumbent firms based on well-established performance metrics, yet they are attractive to customers who make purchases based on price over quality. Students who understand the innovation process through the study and application of its theories can make an immediate impact in their careers. Educators can provide students with foundational innovation education to effectively drive or manage innovation to improve productivity and global competitiveness. For example, the partnership between Proctor and Gamble (P&G) and the University of Cincinnati links students with industry to accelerate innovation for P&G's consumers. This collaborative academic-industry partnership developed a modeling and simulation center to advance P&G's product and process development. As a result of this simulation center, P&G has hired 10 students as full-time employees because they were able to “hit the ground running on day one” (UIDP, 2013, p. 2).

Colleges and universities increasingly offer entrepreneurship-focused academic programs, certificates, and minors (Bordogna, Fromm, & Ernst, 1993; Robinson & Haynes, 1991; Seymore, 2001; Standish-Kuon & Rice, 2002). Although there is growth in entrepreneurship education, there is still a need for educational credentials with a specific focus on innovation. One recent study identified only eight undergraduate academic programs focused on innovation. They included three bachelor degree programs, three minors, and two certificate programs (Duval-Couetil & Dryrenfurth, 2012). Additionally, at the graduate level, Dartmouth University offers a Ph.D. program in innovation by combining engineering and business courses with an applied business or industry internship (Dartmouth, 2011). For the innovation core, Dartmouth combines four engineering courses with four business courses to provide graduates with the foundation to build businesses based on technological innovation.

The Need for Research in Innovation Education

Although an innovation curriculum is gaining popularity, published research on effective teaching and learning methods of innovation education for all students, and more specifically, for engineering and technology students is needed. The Ewing Marion Kauffman Foundation (2012) has recognized this need. The Kauffman Foundation’s mission is to advance entrepreneurship and improve the education of children and youth through four program areas: (a) entrepreneurship, (b) innovation, (c) education, and (d) research and policy. The Kauffman Foundation supports research and publication specific to innovation and innovation education at all educational levels. As one example, Kauffman sponsored the USC Global Innovation Challenge Summer Program, which supports educators who teach students to develop innovative skills to promote business growth in developing countries. As part of a global collaborative effort, this program teams USC students with students in India to develop innovative solutions to local problems. Through this program, students develop projects and launch companies to meet global challenges. To promote research in innovation, the Kauffman Foundation supports dissertation fellowships and junior faculty fellowships for those graduate students and new faculty who establish a record of scholarship in the area of innovation (Ewing Marion Kauffman Foundation, 2012).

If engineering educators are to meet the need for innovation and economic growth (National Academy of Engineering, 2005) it is important to contextualize innovation and innovation education in terms of engineering and technology curricula. Because research overwhelmingly points to a call to action for applied engineering schools to include innovation and innovative thinking in their curriculums (Bordogna et al., 1993; Gopalakrishnan & Damanpour, 1997; Steiner, 1998), it is important to explore not only the need for innovation theory and practice in engineering and technology education, but also to examine successful and effective instructional methods for this population of students. Steiner (1998) suggested innovative engineering education should focus on management and innovation skills as important hallmarks of success in an engineering career, whereas Bordogna et al. (1993) recommended developing the engineer holistically to encourage innovation and not treating engineering education as a serial process with filters and gates. Whether the innovation curriculum is integrated holistically, programmatically, or as a module within an existing course, the opportunity exists for effective curriculum development and implementation that contains problem-based or work-based education that will benefit both the student and the participating partners. Industry and university collaborations provide the framework for engineering technology faculty to incorporate industry-based projects into their research and instruction.

Although engineering as a practice is highly technical and data driven, the education of engineers and engineering technologists is far from scientific. Engineering educators often rely on intuition, or feeling, rather than gathering data and proving which instructional methods are most effective for engineering students in different learning environments. “Unlike the technical community, wherein data-driven results from one lab have widespread impact on the work of peers, many educational reformers have not incorporated research on learning into their work" (National Academy of Engineering, 2005, p. 26). Additionally, because engineering and technology students learn most effectively in a setting that allows them to apply knowledge actively with projects and case studies (Prince & Felder, 2006), university partnerships with business, industry, nonprofits, and government can provide students with the opportunity to work on real-world projects as part of their innovation education. Industry-based projects encourage students to learn and apply knowledge immediately. This situated cognition allows students to understand abstract concepts and procedures while actively deploying theory (Brown, Collins, & Duguid, 1989) in a controlled workplace setting.

Leveraging University-Industry Partnerships for Innovation Education

Universities can form purposeful and meaningful partnerships with industry for the benefit of students. These collaborative partnerships provide students with a relevance to their academic learning process. For example, colleges can use industry-sponsored senior capstone projects for student teams to solve problems or challenges faced by companies. These projects provide students with the opportunity to apply their knowledge and gain valuable experience,

"... students want relevance in the content of their courses and are interested in learning how to do things that will enable them to be successful as practicing engineers. They are also interested in learning things that will be of value to their prospective employers and will be seen as such on their resumes" (Todd & Magleby, 2005, p. 204). Additionally, these partnerships allow companies to access a pool of potential new engineers without the expense of traditional recruiting activities. Further, it is an opportunity for industry to reach out to academic resources to assist them with product or process challenges. Leaders in industry often seek access to research within academia to which they can quickly apply for a competitive market advantage (Todd & Magleby, 2005; Yamada & Todd, 1997). Building upon the foundation of innovation theory, students can be effective pipelines for innovation for industrial partners. Successful frameworks for university-industry partnerships are ones in which all stakeholders benefit through an open line of communication, collaboration, and a well-defined accountability structure. Although industrial and educational collaborations can be successful in many forms, we suggest these partnerships define and document goals and expectations in the following three areas:

Mutual Benefit

First, an industrial partner must see the benefit of partnering with a university. The most effective partnerships between universities and industry are the ones in which the benefits to both parties are explicitly defined and continually revisited. These partnerships should be formed around mutual needs and market demands where there is value added to both parties as a result of the collaboration (Ryan & Heim, 1997). One example of a successful university-industry partnership is the relationship between DuPont and Penn State. Both partners have a shared interest in total quality management (TQM). DuPont sought to outsource research and development in this area, whereas Penn State viewed this as an opportunity to expand research in this area. Penn State and DuPont collaboratively focused on human resource development, continuing education, and technology transfer through this TQM relationship.

Single Point of Contact

Penn State attributes the success of this relationship to maintaining a single point of contact at each organization to drive measurable results. This two-person team "... has taken on the role of technology liaison between the two institutions, each representing the mission and interests of his respective organization" (Ryan & Heim, 1997, p. 43). From this partnership, Penn State expanded its corporate training programs, refined its academic advising process, and revised its manufacturing engineering program's curriculum to better emphasize the "interdependency of design in a business environment" (Ryan & Heim, 1997, p. 44) to benefit both the student and the company.

Defined Research Area

Industrial partners often fund and engage with university centers or technology incubators for the purpose of cooperative research, knowledge transfer, and technology transfer (Santoro, 2000). These centers are primarily focused on one particular research area, for example, energy, the environment, advanced manufacturing with the sole purpose of driving research and innovation within that focus area. Often, similar companies invest in these centers as a consortium to strengthen research and development as an industry (Geisler, Furino, & Kiresuk, 1990). An example of a university-based research center is Carnegie Mellon University's Center for Iron and Steelmaking Research, which is funded by 15 manufacturers associated with the iron and steel industries. Initially the center was funded by the National Science Foundation in 1985, but it has remained self-supporting primarily through funding from industry. The mission of the center is to conduct basic fundamental research to support the efficient production of iron and steel while educating students for these industries. This is accomplished by connecting both graduate and undergraduate students with industry and company-specific research projects (Fruehan, 2006).

However these partnerships are formed and managed, it is through these collaborative efforts universities play a role in economic development by accelerating organizational learning and building communities of innovation (Carayannis, Alexander, & Ioannidis, 2000). Industry-university partnerships spur discovery, promote application of knowledge, and build a more innovative and talented workforce. Others support this view:

> The key then is to move away from the limited concept of the university as an engine of economic development and begin to view the university as a complicated institutional underpinning of regional and national growth. If nations and regions are really serious about building the capacity to survive and prosper in the knowledge economy and in the era of talent, they will have to do much more than simply enhance the ability of the university to transfer and commercialize technology. (Regional partnerships) will have to act on this infrastructure both inside and surrounding the university in ways that make places more attractive to and conducive to talent. (Branscomb, Kodama, & Florida, 1999, p. 607).

Recommendations

Universities have a unique opportunity to contribute to the economic vitality of the regions they serve via connecting students with industry through work-based educational experiences. Students can serve as a pipeline of innovation by applying theoretical and applied knowledge to solve actual industry challenges. Engineering technology educators teach mechanical/electrical theory along with the application of those theories to students for the purpose of product and process design. Instructors can and should incorporate innovation theory into the technology curricula to spur future technology business growth from graduates.

If educators are to meet the growing demand for engineering and technology talent and cultivate an innovation mindset in graduates, further research is needed to identify effective teaching and learning strategies that include work-based learning and case studies in the classroom. To measure the effectiveness of these programs, appropriate metrics should be developed to accurately report the benefits to not only faculty and staff, but also to the companies and regions served through these collaborations. Additional research is needed to assess the learning styles of engineering technologists with regard to the application of entrepreneurship and innovation education.

Universities should address common roadblocks in university-industry collaborative partnerships. The topics of intellectually property ownership, liability, and memorandum of understanding are often debated, ill-defined, and over-negotiated to the point where it is no longer feasible for these partnerships to exist. Often these partnerships are sought out by either the university or the company to exploit a specific opportunity, which can quickly expire before the time the contracts have been agreed upon. Universities should develop and follow a streamlined process for engagement that allows students, faculty, and administrators to be proactive and nimble regarding the needs of their business partners and the regions they serve.

Dr. Christy Bozic is the Director of Workforce and STEM Education for the College of Technology at Purdue University in West Lafayette, Indiana.

Dr. Duane D. Dunlap is a Professor in the School of Engineering Technology at Purdue University in West Lafayette, Indiana. He holds the Epsilon Pi Tau Distinguished Service Citation and is a member of Alpha chapter.

References

Berman, S. (2010). *Capitalizing on Complexity*. Report from IBM Business Services. Somers, USA.

Bordogna, J., Fromm, E., & Ernst, E. W. (1993). Engineering education: Innovation through integration. *Journal of Engineering Education*, *82*(1), 3-8.

Bramwell, A., & Wolfe, D. A. (2008). Universities and regional economic development: The entrepreneurial University of Waterloo. *Research Policy*, *37*(8), 1175-1187.

Branscomb, L. M., Kodama, F., & Florida, R. (1999). *Industrializing knowledge*: University-industry linkages in Japan and the United States   Retrieved from http://books.google.com/books?hl=en&l =&id=OfrC8kEev1QC&oi=fnd&pg=PR9&dq=Industrializing+knowledge:+Univers ty-industry+linkages+in+Japan+and+the+United+States&ots=6CFvwzMrEu&sig=agawOAcRott dO5j15nx7nkWJ1o

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32-42.

Carayannis, E. G., Alexander, J., & Ioannidis, A. (2000). Leveraging knowledge, learning, and innovation in forming strategic government–university–industry (GUI) R&D partnerships in the US, Germany, and France. *Technovation*, *20*(9), 477-488.

Christensen, C. M. (1997). *The innovator's dilemma: When new technologies cause great firms to fail*. Boston, MA: Harvard Business Press.

Christensen, C. M. (2012). Bio, beliefs, ideas in action, key concepts, latest thinking. Retrieved from www.claytonchristensen.com

Christensen, C. M., Anthony, S. D., & Roth, E. A. (2004). Seeing what's next: U*sing the theories of innovation to predict industry change*. Boston, MA: Harvard Business Press.

Christensen, C. M., & Raynor, M. E. (2003). *The innovator's solution: Creating and sustaining successful growth*. Boston, MA: Harvard Business Press.

Council on Competitiveness. (2005). I*nnovate America: Thriving in a world of challenge and change*. Paper presented at the National Innovation Initiative Summit, Washington, DC.

Dartmouth. (2011). Ph.D innovation programs and fellowships. Retrieved from http://engineering. dartmouth.edu/academics/graduate/innovation/

Deason, G. (2008). *Purdue University and economic development: Defining the 21st centry land grant university*. Economic Development Working Group. Purdue Univeristy.

Drucker, P. F. (1998). The discipline of innovation. *Harvard Business Review*, *76*(6), 149-157.

Duval-Couetil, N., & Dryrenfurth, M. (2012). *Teaching students to be technology innovators: Examining approaches and identifying competencies*. Paper presented at the American Society for Engineering Education Annual Conference, San Antonio, TX. http://www.asee.org/public conferences/8/papers/4817/view

Dyer, J. H., Gregersen, H. B., & Christensen, C. M. (2009). The innovator's DNA. *Harvard Business Review*, *87*(12), 61-67.

Ewing Marion Kauffman Foundation. (2012). Ewing Marion Kauffman Foundation. Retrieved from www.kauffman.org

Fruehan, R. J. (2006). Center for iron and steelmaking research, 2012. Retrieved from http://neon.mems.cmu.edu/cisr/about/index.html

Geisler, E., Furino, A., & Kiresuk, T. J. (1990). Factors in the success or failure of industry-university cooperative research centers. *Interfaces*, *20*(6), 99-109.

Gopalakrishnan, S., & Damanpour, F. (1997). A review of innovation research in economics, sociology and technology management. *Omega*, *25*(1), 15-28.

Green, J. V., Smith, J. A., & Warner, J. R. (2012). First year review of the entrepreneurship and innovation program (EIP) at the University of Maryland. *The Journal of Engineering Entrepreneurship*, *3*(1), 8.

Milliken, J. B. (2012). The innovation and competitiveness agenda 2012 - A summary of suggestions from business and education leaders for areas of engagement and focus in innovation and competitiveness: Association of Public and Land-grant Universities, Commission on Innovation, Competitiveness and Economic Prosperity

Mogee, M. E. (1993). Educating innovation managers: Strategic issues for business and higher education. *IEEE Transactions on Engineering Management*, *40*(4), 410-417.

National Academy of Engineering. (2005). *Educating the engineer of 2020: Adapting engineering education to the new century*. Washington, DC: National Academies Press.

National Science Foundation. (2012). *Science and engineering indicators* 2012. (NSB12-01). January 2012: Retrieved from http://www.nsf.gov/statistics/seind12/c3/c3h.htm.

Orr, J. A., & Eisenstein, B. A. (1994). Summary of innovations in electrical engineering curricula. *IEEE Transactions on Education*, *37*(2), 131-135.

President's Council of Advisors on Science and Technology. (2004). *Sustaining the nation's innovation ecosystem: Maintaining the strength of our science and engineering capabilities*. Retrieved from http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-04-sciengcapabilities.pdf.

Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education*, *95*(2), 123.

Robinson, P., & Haynes, M. (1991). Entrepreneurship education in America's major universities. *Entrepreneurship Theory and Practice*, *15*(3), 41-52.

Ryan, J. H., & Heim, A. A. (1997). Promoting economic development through university and industry partnerships. *New Directions for Higher Education*, *1997*(97), 42-50.

Sandeen, C. A., & Hutchinson, S. (2010). Putting creativity and innovation to work: Continuing higher education's role in shifting the educational paradigm. *Continuing Higher Education Review*, *74*, 81-92.

Santoro, M. D. (2000). Success breeds success: The linkage between relationship intensity and tangible outcomes in industry–university collaborative ventures. *The Journal of High Technology Management Research*, *11*(2), 255-273.

Seymore, N. (2001). ERIC Clearinghouse on Entrepreneurship Education, L.A. *Entrepreneurship Education in American Community Colleges and Universities.*

Smith, T. R., Drabenstott, M., & Gibson, L. (1987). The role of universities in economic development. *Economic Review*, *72*(9), 3-21.

Standish-Kuon, T., & Rice, M. P. (2002). Introducing engineering and science students to entrepreneurship: Models and influential factors at six American universities. *Journal of Engineering Education*, *91*(1), 33-40.

Steiner, C. J. (1998). Educating for innovation and management: The engineering educators' dilemma. *IEEE Transactions on Education*, *41*(1), 1-7.

Todd, R. H., & Magleby, S. P. (2005). Elements of a successful capstone course considering the needs of stakeholders. *European Journal of Engineering Education*, *30*(2), 203-214.

UIDP. (2013). Procter & Gamble / University of Cincinnati Simulation Center. *University-Industry Demonstration Partnershp*. Retrieved from http://sites.nationalacademies.org/pga/uidp pga_072996

White House Office of the Press Secretary. (2011). *Remarks by the president in state of union address*. Retrieved from http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state union-address

Wolfe, D. A. (2005). Innovation and research funding: The role of government support. In F. Iacobucci & C. Tuohy (Eds.), *Taking public universities seriously* (pp. 316-340). Toranto, Canada: University of Toronto Press Incorporated.

Yamada, T., & Todd, R. H. (1997). The quest for relevance: Roles for academia and industry in Japan and the US. *Journal of Engineering Education*, *86*, 341-348.

It's a "Clicker," not a Magic Wand: The Effect of a Classroom Response System on Attendance

By Raoul Amstelveen

Abstract

This study employed a rank-based nonparametric test to examine the effectiveness of a Classroom Response System (also known as a "clicker") on attendance. A Mann-Whitney U test revealed that attendance in the clicker class (experimental group) and attendance in the nonclicker class (control group) did not differ significantly. However, a survey of 28 participants in the clicker class showed that learners had positive perceptions of clickers. Two focused group sessions in the clicker class also revealed that learners enjoyed using clickers and that they found the clicker technology engaging, interactive, and entertaining.

Key words: Attendance; Nonattendance; Engagement; Classroom Response System (CRS); Clicker; Introductory Statistics

Introduction

Nonattendance in higher education is not only a local or national problem—it is also a universal problem (Barlow & Fleischer, 2011; Cleary-Holdforth, 2007). Nonattendance is such a complex and pesky issue in higher education that researchers do not agree on the depth or scope of the problem. Some researchers argue that student nonattendance is getting worse and is now trending upward (Massingham & Herrington, 2006), whereas others maintain that it has always been a problem (Rodgers, 2002). At the very least, nonattendance has been a major issue in higher education for the last four decades (Romer, 1993). Even though Romer's findings regarding nonattendance have sparked renewed debate about why students do not attend, to date there have not been any unified conceptual models or attempts to provide generalized theory concerning nonattendance among learners in higher education. This lack of generalized theory makes it more difficult to analyze nonattendance among students in higher education. Also troublesome is that introductory statistics can be an arduous and unpleasant subject for many nonscience majors (Bradley, 2009). When students reluctantly attend, they often appear unmotivated, disengaged, and disinterested in the lectures.

Literature Review

The quality of lectures has been documented as playing an integral role in attendance rates. Not missing lectures could be explained with reference to (a) the enthusiasm of the lecturer, (b) a sufficient level of activity and participation in the course, and (c) a clearly structured classroom (Revell & Wainwright, 2009). For instance, Hunter and Tetley (1999) concluded that students want lectures that are interesting, informative, and difficult to make up. In their study, students who were surveyed cited that the number one reason for not missing lectures was an expectation that the lectures would be interesting. The instructor's personality also appears to have a dramatic effect on whether or not students attended a lecture (Massingham & Herrington, 2006; Revell & Wainwright, 2009; van Schalkwyk, Menkveld, & Ruiters, 2010). According to Massingham and Herrington (2006), instructors who are charismatic, humorous, likeable, and energized are more likely to motivate students to attend lectures. Furthermore, teachers who develop meaningful lessons (Dolnicar, 2005) and focus on themes, concepts, and principles appear to make it more worthwhile for students to attend (Fitzpatrick, Cronin, & Byrne, 2011). Fitzpatrick et al. concluded that the main reason students attend lectures is because of quality teaching that actively engages learners in critical topics. Therefore, students will attend as long as they perceive "value" in attending, and one way to exude value is for teachers to be competent in their instruction (Massingham & Herrington, 2006, p. 84).

Efforts to increase active learning have made Classroom Response Systems (CRS)—also known as "clickers"—popular tools in higher education. Clickers are hand-held electronic devices similar to TV remote controls or mobile cellular phones that allow students to transmit their responses onto a screen where they can be automatically tabulated and summarized by software. The overall class results may then be stored, tallied, graded, and formalized into a bar graph or pie chart for the entire class. Clickers are being increasingly used, and they appear to be the gateway for newer response systems and technologies that utilize mobile devices in higher education. For instance, the company iClicker boasts that its technology is used by more than 1,300 higher education institutions (www.iclicker.com).

In a literature review of 67 studies, Kay and LeSage (2009) supported the claim that attendance does improve in clicker classes, especially when clickers are attached to the final grade. According to Dunham (2009), even using motivational incentives as small as an extra two percent toward a student's final grade encourages attendance among clicker users in introductory statistics courses at the University of British Columbia. Therefore, when clickers are connected with points toward the final grade, class attendance increases (Dunham, 2009; Kay & LeSage, 2009). However, instead of conducting headcounts of the total number of students in class, the majority of research studies that have investigated nonattendance in higher education have been correlational in nature. Moreover, most studies rely on students' perceptions and therefore employ survey techniques (e.g., Gok, 2011; Gupta, 2010; Prather & Brissenden, 2009).

It is also important to note that reviews of the connection between clickers and improved attendance do not always produce positive results. For instance, Laxman (2011) conducted a survey in 12 engineering courses consisting of 640 students and found that about 49% of participants claimed that clickers did not motivate them to attend. Other researchers reported no significant changes in attendance as a result of using clickers (King & Robinson, 2009). Some researchers even argued that clickers actually may be detrimental when used to monitor attendance, because students disliked losing marks for missing classes (Milner-Bolotin, Antimirova, & Petrov, 2010).

Theoretical Framework

The theoretical framework upon which this particular study is based is the worker attendance model. According to Steers and Rhodes (1978), the conceptual attendance model (also known as the pain-avoidance model) posits that attendance is influenced by subjects' motivation to attend and by their ability to attend. Furthermore, motivation to attend is partly dependent on how satisfied the workers are with their job situation, as well as other pressures to attend. This is analogous to the learners' level of satisfaction with their course and the decision to attend or nor not attend (Clark, Gill, Walker, & Whittle, 2011). Allen's (1981) labor-leisure model represents another example in which workers weigh the outcome of labor (attending) versus leisure (not attending). The perceived outcome that outweighs the other will win. This study intends to establish a link between absence theories regarding workers and nonattendance theories for students in higher education.

Hypothesis

This study made the following hypothesis:

H0: There is no difference in the mean ranks (median) attendance rates among learners in introductory statistics classes who use clickers and learners in introductory statistics classes who do not use clickers.

H1: There is a difference in the mean ranks (median) attendance rates among learners in introductory statistics classes who use clickers and learners in introductory statistics classes who do not use clickers.

Methodology

This study employed a nonprobability sampling technique to select two introductory sections taught by the author during the 2012-2013 winter academic term.

iClicker

There are many brands of clicker response systems, such as TurningPoint, iClicker, Hyper-Interactive Teaching Technology, Qwizdom, InterWrite PRS, eInstruction, and Option Technology Interactive. Mobile devices (such as smart phones) are becoming increasingly popular and may become the latest trend in higher education. However, the author chose the iClicker 6.1 version because of its portability, ease of use, and relatively low cost for students. More important, the university at which the study was conducted supports iClickers and has class sets available for instructors who wish to implement CRS into their courses. Therefore, participants in this study did not need to purchase clickers because a class set was available.

Participants

The study was conducted in a small-sized, private, undergraduate university located in South Florida. The sample consisted of 68 learners enrolled in two introductory statistics sections taught by the author during the 2012–2013 winter academic term. Of the 68 participants, 33 learners used clickers (treatment group) and 35 learners did not use clickers (control group). The nonclicker section met on Tuesdays and Thursdays, whereas the clicker class met on Mondays and Wednesdays. Both sections met in the early afternoon. The Monday-Wednesday class was chosen as the treatment group because nonattendance had been higher on those days. Moreover, by choosing the Monday-Wednesday class as the treatment group, the effectiveness that clickers had on attendance could be determined based on statistically significant results (Wood, Burke, Da Silva, & Menz, 2007). The clicker and nonclicker classes were similar in terms of gender, age, class standing, and GPA (see Table 1).

Procedure

Learners in the clicker class used clickers during every scheduled meeting except the first meeting, during examinations, and during the last two lecture meetings. Meanwhile, learners in the nonclicker class did not use clickers at any point during the term. Participation in the nonclicker class was based on the percentage of classes that learners attended. In the clicker

Table 1. Demographics of Participants in Clicker and Nonclicker Classes (N = 68)

Variable	Frequency		Percent	
	Clicker	Nonclicker	Clicker	Nonclicker
Age				
18-19	9	11	27.3	32.4
20-21	12	17	36.4	50.0
22 and older	12	6	36.4	17.6
Total	33	34		
Gender				
Female	16	19	48.5	54.3
Male	17	16	51.5	45.7
Total	33	35		
Class Standing				
Freshman	1	0	3.0	0.0
Sophomore	9	15	27.3	42.9
Junior	11	13	33.3	37.1
Senior	12	7	36.4	20.0
Total	33	35		
Ethnicity				
African-American	7	13	21.2	37.1
Hispanic	9	15	27.3	42.9
White Non-Hispanic	13	6	39.4	17.1
Other	4	1	12.1	2.9
Total	33	35		
Grade Point Average				
0.00 - 2.99	8	13	25.8	43.3
3.00- 4.00	23	17	74.2	56.7
Total	31	30		

class, participation was determined based on the number of clicker points. To eliminate anxiety about clicker scores, learners were allowed to earn one point for correct clicker responses and one-half a point for incorrect responses. Participation in the clicker and nonclicker class course counted 5% toward a student's final grade. A clicker participation grade of 5% was deemed reasonable (e.g., Fitzpatrick et al., 2011; Milner-Bolotin et al., 2010), because this percentage was not so weighty as to impose anxiety about statistics or clicker questions yet it was sufficiently high that students would be likely to take clicker questions seriously. It was also theorized that this strategy would reduce the likelihood of students attending solely for the purpose of earning clicker participation points.

iClicker questions were always predesigned and used in conjunction with a PowerPoint slide. Clicker questions were usually asked toward the end of the lecture, except when students appeared to be tired, bored, or weary from the lecture. At those times, clicker questions were used during the middle of the session. Clicker questions in the middle of the lecture provided a nice change of pace, and they provided students with a break from standard lecture formats. When clicker questions were used in the beginning of the lecture, students who arrived late often lost clicker points. During the focus group sessions, participants mentioned that they were frustrated by clicker questions that were asked at the beginning of the period; they preferred the clicker questions to be asked at the end (or at least at the beginning and the end) of the lecture. During clicker questions, students spoke freely among themselves, clarifying, confirming, and analyzing clicker questions. They sometimes blurted out the answers without giving other students an opportunity to try it out for themselves. However, such actions were allowed because they indicated that students were engaged in the lesson. Each time clicker questions were asked, there was a visible increase in "noise" and enthusiasm, which was encouraged because it seemed that students were learning both individually and cooperatively.

Clicker questions posed in the clicker class were taken from the current textbook used in the institution, from other textbooks, or from other researchers. For example, Figure 1 illustrates a modified clicker question from

Figure 1. iClicker modified question

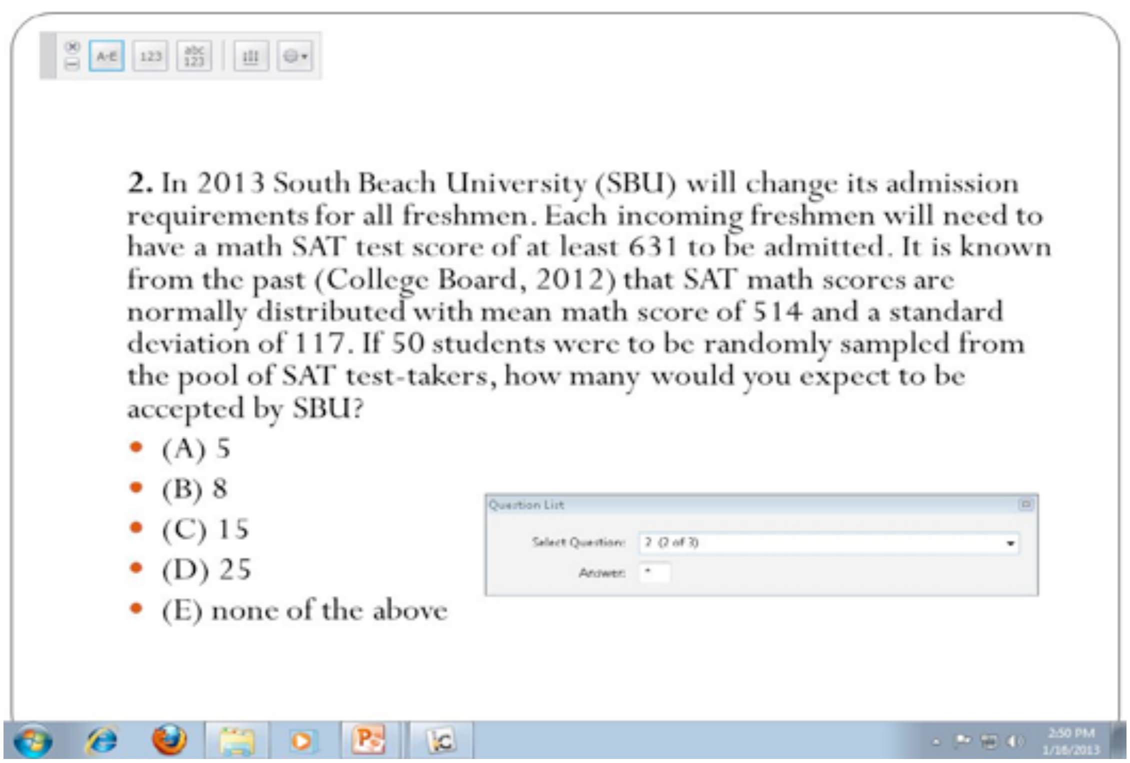
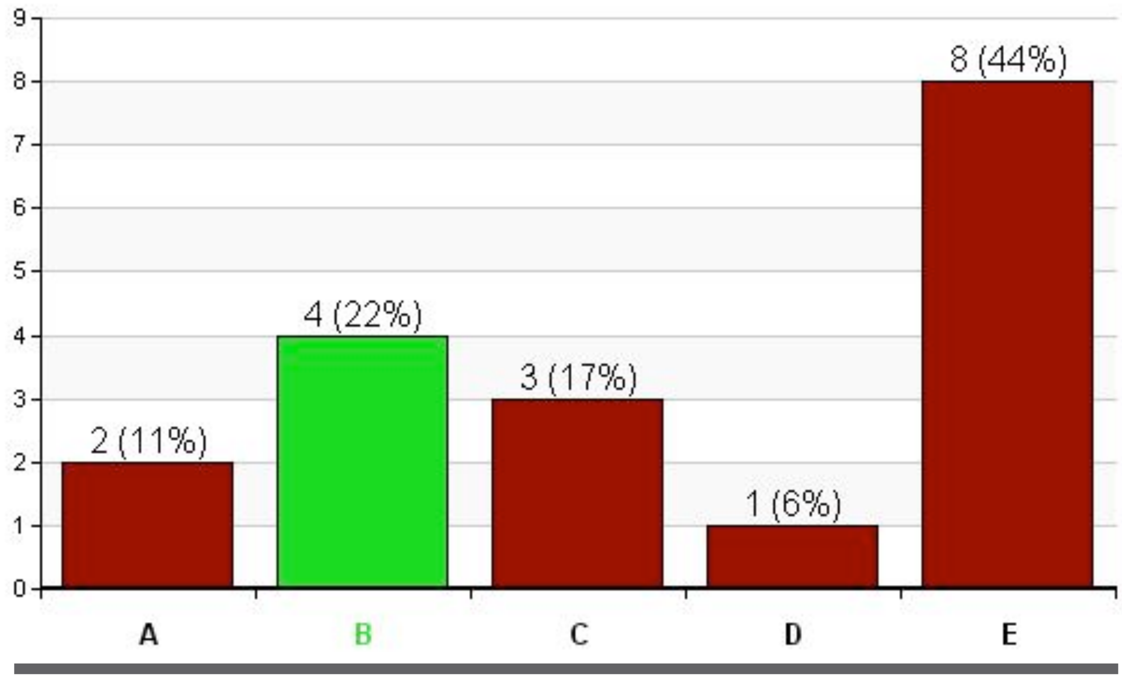


Figure 2. Clicker response



Murphy, McKnight, Richman, and Terry (2008) with values changed and the name of the university changed. In this example, only 22% of the students answered the question correctly (Figure 2), which provided the perfect opportunity to clarify some misunderstandings regarding the Empirical rule and the standard normal distribution. These results also illustrate the benefits of clickers, since the results are anonymous. This enables teachers to instantly gauge whether or not students understand a particular concept.

Results

Attendance versus Nonattendance

Attendance in both classes was taken using headcounts. Student who arrived late were counted as present. To double-check attendance in the clicker class, participation data records from iClickers were utilized. Figure 3 illustrates the attendance rates and trends based on headcounts conducted in both the clicker and nonclicker classes.

The 7th lecture was conducted on the last day of lectures prior to the Christmas holiday, and many students chose not to attend. Focus group participants provided reasons for not attending. Further, clickers were not used during the last two lecture meetings because students needed to work on their class projects. Each term, individual class projects are assigned, and they are worth 20% of each student's final grade. Based on Figure 3, attendance rates between the clicker and nonclicker classes appeared similar. Because participants were not randomly assigned to the clicker and nonclicker classes, a Mann-Whitney U test was run to determine if there were differences in attendance rates between the two groups. The median attendance rate for the clicker class (78%) and nonclicker class (82%) was not statistically significantly different, $U = 107.5$, $p = .43$, using an exact sampling distribution for U (Dineen & Blakesley, 1973).

To analyze how students perceived the clicker technology, 28 out of 33 students in the clicker class volunteered to complete a survey centered on a "clicker efficacy" scale developed by Haeusler and Lozanovski (2010). Each item on the "clicker efficacy" scale used a five-point Likert scale where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree (see Table 2). The instrument has an inter-item reliability of .89 and has been shown to be reliable based on the survey results given to science students (Haeusler & Lozanovski, 2010). On average, participants had positive perceptions about using clickers ($M = 3.77$, $SD = .70$), and the majority of students perceived clickers to be a

Figure 3. Attendance rates in clicker and nonclicker classes

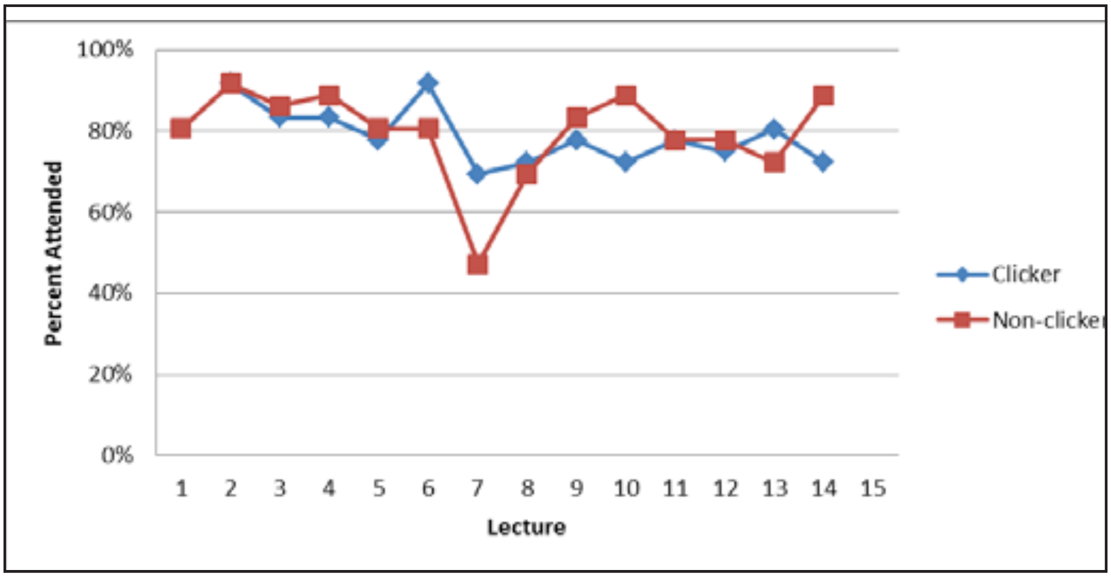


Table 2. Likert Questions on Student Perception of Clickers

Table 2. Likert Questions on Student Perception of Clickers

Question	% Agree	% Neutral	% Disagree	Mean ± SD
1. Using the clickers showed me where I stood in relation to the rest of the class.	54%	39%	7%	3.71 ± .94
2. Using the clickers helped me identify areas of strength and weakness in content knowledge.	78%	18%	4%	3.82 ± .91
3. Using the clickers made the classes interesting and engaging.	64%	22%	14%	3.61 ± 1.10
4. Using the clickers prompted discussions.	64%	25%	11%	3.71 ± 1.01
5. Using the clickers was a waste of time. ¥	14%	11%	75%	4.07 ± 1.09
6. Using the clickers assisted my understanding of the concepts that were discussed.	21%	43%	36%	3.75 ± .80
7. Using the clickers did not assist my learning. ¥	71%	22%	7%	3.86 ± .97

Note. ¥ denotes reverse coded item.

useful tool for introductory statistics. On average, learners also felt that clickers increased levels of engagement and made the class interesting. The question with the highest rated score was the reverse coded question: "Using the clickers was a waste of time." Thus, students indicated that they found the clicker technology to be a worthwhile addition in the course. Interestingly, 71% of the participants did not feel that clickers assisted their learning. This may be partly explained by the fact that the clicker questions did not align very well with examination questions; also, the participants' dissatisfaction with conducting the clicker questions at the beginning of the lecture may also have played a role.

Focus Group Results

Two focus group sessions also were conducted in the clicker class in order to analyze students' perception of clickers and their reasons for attending and not attending classes. The sessions consisted of 10 men and 10 women, and member checking was conducted after the group sessions to ensure the accuracy of the transcribed report. From the focus group sessions, five major themes emerged as factors that influence the likelihood of attendance: (a) medical emergencies and illnesses, (b) work, (c) college tuition costs/financial obligations, (d) time and day of the class, and (e) instructor/ facilitator.

Although reasons such as medical emergencies and illness are out of the hands of the instructor and have been documented in other research studies (e.g., van Schalkwyk et al., 2010), these same themes were again reported in the focus groups. For example, one participant stated, “The only time that I actually missed class was when I was sick or I really couldn’t make it to class.” Another participant reported similar reasons: “I was either sick or I just didn’t wake up for class.” The scheduled time of the class also seemed to influence attendance. Early morning classes, especially on Mondays, tend to be attended at a lower rate. One participant compared morning classes with the clicker class, revealing a tendency to miss morning classes but not classes in the middle of the day: “I’m usually awake by this time. For an 8:00 a.m. class, sometimes I just don’t wake up.” Some students try to attend even when they are sick. For example, one participant stated: “I would never miss a class, even if I was sick. Yes, I try not to. I don’t want to get too far behind.”

However, competing commitments and financial obligations can make it difficult for many students to attend. Often, students must choose between attending class and going to work. One participant stated the following:

> Most of the times like me it’s two jobs and sometimes my second job wants me to come on certain days, usually in time frames where this class is going on. So do I need rent money, or do I need to come to class? Rent is naturally the first priority so that you can have a roof over your head, so that’s why I sometimes don’t come to class.

Another student explained how work and family commitment contributed to her nonattendance:

> I work over 40 hours a week, so it’s kind of the reason why I don’t put my priorities in order in the best way, and if I’ve missed class it’s because I was out of state because that’s where my family is.

Therefore, students typically feel like attendance is not an option when they need to work, experience an illness, or are involved in other medical emergencies. One participant stated: “Either I’m really sick or at work. I actually have a job to go to.” Although all participants agreed that it is important to attend classes, there are cases in which their failure to attend is simply a result of the weather. Although one would expect bad weather to increase nonattendance, the focus groups indicated that good weather also invites poor attendance. For example, one participant stated:

> Just to share, when the weather is extremely good or bad you don’t want to spend that period in the classroom; you want to be at home or outside. I had friends that flew up. I just hung out with them like a week or two, so I thought it was worth it to skip a class or [to] to spend time with them. They’re only going be here a maximum of five days. So I chose to skip a class or two.

However, there are times when students simply do not attend because of instructional practices or a dislike of the instructor. One participant explained how he only attended a few times as a result of the instructor:

> Yes, I hated the professor. Like, [we] did not get along. So I said “You know what, here’s my homework—I’m not going to show up until the final.” We had like six papers, and I handed in all my assignments at the beginning of the semester. I had this person before, and we had a personal issue. I was like, “Give me my assignments and I will see you on the final.”

Although the diversity of the campus is often embraced by students, faculties, and the administration, many foreign students leave early, before a break such the Christmas holiday and arrive after classes have started. This pattern was evident on the 7th lecture day shown in Figure 1. For example, one participant said, “Sometimes I might go back to my country, so I will ask to leave early and do a make-up test another day.”

However, students are encouraged to attend by caring teachers who are able to develop a good relationship with their students and by teachers who are effective at presenting course material. For example, one participant was encouraged to attend classes solely because of the instructor. She stated:

> It goes back to why you attend the class regularly. Like, if the professor is making an effort to show up to teach you something, why not be there? So they do care. Often times, if they didn't care, they would tell you at the front door, "Get outta my class."

When courses are challenging for students (as introductory statistics courses often are), students also tend to attend at a greater rate. Therefore, the difficulty of a course seems to motivate students to attend. For example, one participant concluded that:

> The subject that I excel in I tend not to go as much versus a class that I don't know what's going on in. I try to show up more because I won't understand it if I don't attend.

Another participant tried to clarify and explain how and why he attended some classes:

> More like hard science classes you got to attend more, because if you miss like one part, you're not going to be able to move on. Classes like law classes something like that, you could miss one part of the subject and still be able to pick up next class. They tend to be interlinked but not dependent on each other. So, like, math classes and science classes tend to be more dependent upon one another.

Thus, attendance is promoted by teachers who are able to engage students and make the lesson and classroom environment exciting and fun for students. One participant recalled an experience in one of her courses:

> I had a professor two years ago who used to take the classroom experience and change it every time you went. He'll do one thing one day and another day something else. Because it was marketing, we'll play video games and then he'll go back and forth and joke and then we're having a meeting at another place at another time, and I think that was really entertaining because we didn't know what was going to happen. So, I think if classes were more like that they will draw more attention.

Another participant echoed a similar response:

> I will base it on the professor. The professor usually makes me want to come or not come every day. Usually if the professor is good and teaches you well, and you're actually learning and comprehending what they're saying, then yes, I'll be in class regularly.

Interestingly, the majority of participants preferred to be "forced" to attend if the instructor used participation points rather being mandated to attend by a mandatory attendance policy. One participant concluded that he would not attend classes if participation points were not part of the overall assessment in a course:

> Honestly, for me, I try to attend classes that are graded based on participation. For example, all these clickers motivated me to be present just because I know for a fact I'm losing something just for not showing up. But there are classes that don't require it.

However, the vast majority of participants enjoyed clickers, especially since they did not need to purchase them. For example, one participant stated:

> I like the clickers because I know like me some kids aren't like as vocal in class so maybe like their participation isn't as like high. I'm pretty loud all the time, but in Statistics, I'm not that smart, so I like that there's a clicker to help me with my participation grade. I also like that that this year we didn't have to buy them. Because I know freshman year I still have my clicker in this bag that I bought in one class so this is good for the upcoming kids. I know it stinks because you have to carry it [clicker set] to class everyday but is better than to spend $100 on a clicker that I used once.

Another participant explained how the classroom environment improved as a result of clickers:

> I feel like it makes the class a little bit more entertaining. Relating technology with the student. It makes them focus more or at

> least in my case. People are playing like they will shout out the answer, but if you actually look at it, you think about the question while you're sitting in your seat which answer you're going to choose and you do sit there and work it out and sometimes you do get the answer correct.

I heard similar responses in other lectured sessions when participants seemed disappointed when clicker questions were finished. All participants enjoyed the immediate feedback that clickers provided. One student agreed and added that clickers reduced her stress level when solving introductory statistics clicker problems:

> I think it takes away the anxiety of you taking a quiz and you handing it oh crap how did I do on that question. You get the immediate gratification that boom you clicked the answer it pops up and you know I either got the answer or I didn't. And you move on to the next one. You're no longer thinking about how did I do on that question. So a lot of times you don't know until the next class period and it's like two days later you go crap how did I do on that quiz.

However, focus group participants did not like it when students shouted out some of the answers before the clicker responses and answers were displayed. One participant suggested that I "make everyone not talk" during the clicker questions. Another participant explained that "sometimes when you're not sure, people shout out the answers, so then you pick that answer you get it wrong." Another participant explained the classroom environment:

> Because it's so interactive, people tend to take it more as a joke. When there's a quiz, it's all right you have to be quiet. With clickers, people tend to just play around more. So, they do tend to shout out the answer more, and it can screw you up. You get that self-doubt like so and so said that answer and they might be right.

Limitations

Ideally, participants would have been randomized when it came to creating the clicker and nonclicker classes. However, these participants could not be randomized, as they chose whether to be in the clicker or nonclicker class, though they were not aware of which section the intervention was going to be used in. Finally, even though the data was triangulated and every effort was made to ensure consistency in the treatment of participants in both classes, it is possible that learners from one group were unknowingly encouraged or motivated to attend more classes than the other group.

Discussion

The results from this study are consistent with other research findings. For instance, Morling, McAuliffe, Cohen, and Dilorenzo (2008) concluded that "attendance neither increase[s] nor decrease[s] over the semester" with clickers (p. 48). King and Robinson's (2009) study of 145 undergraduate engineering students also reported no statistically significant differences in attendance rates resulting from clicker use, "based on classroom observations" between a 2007–2008 cohort and a 2006–2007 cohort (p. 197). Further, Trenholm and Dunnet (2007) observed that "students not using clickers had even higher mean attendance levels than students using clickers" (p. 6). In their study, one section used clickers, one section did not use clickers, and one section was mixed. In the mixed section, some participants used clickers while others did not use clickers. Although the mixed class had a slightly higher attendance rate, the difference was negligible and nonsignificant.

All participants agreed that it was important to attend classes and admitted to being aware of the possible negative consequences of not attending. Nonetheless, students still had reasons to not attend. One participant stated: "I miss class sometimes because I'm sick. Sometimes, I'm just not feeling it for the day, or I just don't feel like listening to the teacher. It's bad, though." These results support the findings of Shannon (2006) and Doyle et al. (2008), which show that illnesses and medical emergencies decrease attendance. Other major reasons for not attending include spending time with friends or family, completing assignments for other classes, traveling, and particularly good or bad weather. These results were echoed in van Schalkwyk, et al.'s (2010) study. Poor teacher relationship and the quality of the lecture also contribute to nonattendance among participants. These results parallel the findings of Newman-Ford, Fitzgibbon, Lloyd, & Thomas (2008) and Doyle et al. (2008).

Missing classes due to financial obligations is a major theme that emerged during the focus group sessions. Participants expressed dissatisfaction about high tuition costs and resented being required to purchase clickers in the past. These financial obligations were seen as putting a strain on their ability to attend due to a need to work. Not attending as a result of part-time and full-time work was the most frequent reason for not attending. These findings support several previous studies (e.g., Doyle et al., 2008; van Schalkwyk et al., 2010).

Future Implications

This study suggests that when clickers are linked with a participation grade of five percentage points or less, attendance does not increase. Therefore, clickers do not magically increase attendance. A well-prepared, motivated, and caring lecturer who encourages participation and is able to establish a relationship with students is more likely to improve attendance and, in turn, can enhance the effect that clickers have on learners. Researchers interested in replicating this study should consider implementing clickers during other timeslots and on other days besides Mondays and Wednesdays to determine if similar nonsignificant results are obtained. Furthermore, because the majority of learners in this study had a positive perception of clickers, but they had reservations regarding the timing of clicker questions; in the future researchers should consider conducting clicker questions only during the middle or at the end of the lecture—not at the beginning.

Conclusion

Research studies on attendance in introductory statistics are limited. Besides work commitments, medical emergencies, and other uncontrollable factors, students cite boring classes, ineffective lectures, and a dislike of the lecturer as significant reasons to not attend (Fitzpatrick et al., 2011). However, the lecturer can attempt to influence students' behavior to attend by using the clicker technology to engage students while they remain anonymous. Even though the findings from the study revealed there were no statistically significant differences in attendance rates between learners in the clicker and nonclicker classes, clickers can change a classroom environment from a quiet, lecture-centered session into a game-like atmosphere that encourages communication and participation. Learners perceive the technology to be interactive and entertaining and they prefer earning participation points using the clicker technology rather than by listening to a teacher-centered lecture. Some participants even feel that the clicker technology reduces their stress level and provides a visual approach to learning. These attributes add a positive experience for learners and invite the implementation of other mobile devices (i.e., smartphones and tablets) into classrooms regardless of students' attendance records.

Raoul Amstelveen is an Associate Professor at Johnson and Wales University, North Miami, Florida.

References

Allen, S. G. (1981). An empirical model of work attendance. *Review of Economics & Statistics, 63*(1), 77.

Barlow, J., & Fleischer, S. (2011). Student absenteeism: Whose responsibility? *Innovation in Education and Teaching International, 48*(3), 227-237.

Bradley, C. (2009). Learning to live with statistics: From concept to practice. *Teaching Sociology, 37*(3), 322-324.

Clark, G., Gill, N., Walker, M., & Whittle, R. (2011). Attendance and performance: Correlations and motives in lecture-based modules. *Journal of Geography in Higher Education, 35*(2), 199-215.

Cleary-Holdforth, J. (2007). Student truancy in higher education. A phenomenon of student apathy or poor pedagogy? *Dublin Institute of Technology, Level 3*, 5. Retrieved from http://level3.dit.ie/html/issue5/cleary-holdforth/cleary_holdforth.pdf

Dineen, L. C., & Blakesley, B. C. (1973). Algorithm AS 62: Generator for the sampling distribution of the Mann-Whitney U statistic. *Applied Statistics, 22*, 269-273.

Dolnicar, S. (2005). Should we still lecture or just post examination questions on the web? The nature of the shift towards pragmatism in undergraduate lecture attendance. *Quality in Higher Education, 11*(2), 103-115.

Doyle, L., O'Brien, F., Timmins, F., Tobin, G., O'Rourke, F., & Doherty, L. (2008). An evaluation of an attendance monitoring system for undergraduate nursing students. *Nurse Education in Practice, 8*(2), 129-39.

Dunham, B. (2009). *Statistics clicks: Using clickers in introductory statistics courses*. Retrieved from http://www.cwsei.ubc.ca/SEI_research/files/Stat/ BDunham _ClickersInStat.pdf

Fitzpatrick, J., Cronin, K., & Byrne, E. (2011). Is attending lectures still relevant in engineering education? *European Journal of Engineering Education, 36*(3), 301-312.

Gok, T. (2011). An evaluation of student response systems from the viewpoint of instructors and students. *Turkish Online Journal of Educational Technology, 10*(4), 67-83.

Gupta, M. L. (2010). Interactive teaching and learning by using systems. *The International Journal of Learning, 17*(5).

Haeusler, C. E., & Lozanovski, C. (2010, December) *Student perception of clicker technology in science and mathematics education.* Paper presented at the 2010 Enhancing Learning Experiences in Higher Education Conference, Hong Kong. Retrieved from http://eprints.usq.edu.au/18154/1 / Haeusler_Lozanovski_2010_2 _PV.pdf

Hunter, S., & Tetley, J., (1999, July). Lectures. Why don't students attend? Why do students attend? Paper presented at the *HERDSA Annual International Conference*, Melbourne, Australia.

Kay, R. H., & LeSage, A. (2009). Examining the benefits and challenges of using audience response systems: A review of the literature. *Computers & Education, 53*, 819-827.

King, S. O., & Robinson, C. L. (2009).'Pretty lights' and maths! Increasing student engagement and enhancing learning through the use of electronic voting systems. *Computers & Education, 53*(1), 189-199.

Laxman, K. (2011). A study on the adoption of clickers in higher education. *Australasian Journal of Educational Technology, 27*(8), 1291-1303.

Massingham, P., & Herrington, T. (2006). Does attendance matter? An examination of student attitudes, participation, performance and attendance. *Journal of University Teaching and Learning, 3*(2), 82-103.

Milner-Bolotin, M., Antimirova, T., & Petrov, A. (2010). Clickers beyond the first-year science classroom. *Journal of College Science Teaching, 40*(2), 14-18.

Morling, B., McAuliffe, M., Cohen, L., & Dilorenzo, T. M. (2008). Efficacy of personal response systems ("clickers") in large introductory psychology classes. *Teaching of Psychology, 35*, 45-50.

Murphy, T. J., McKnight, C., Richman, T., & Terry, R. (2008). *Clicker questions*. Retrieved from The University of Oklahoma, http://www.ou.edu/statsclickers /clickerQuestions.htm

Newman-Ford, L., Fitzgibbon, K., Lloyd, S., & Thomas, S. (2008). A large-scale investigation into the relationship between attendance and attainment: A study using an innovative, electronic attendance monitoring system. *Studies in Higher Education, 33*(6), 699-717.

Prather, E. E., & Brissenden, G. (2009). Clickers as data gathering tools and students' attitudes, motivations, and beliefs on their use in this application. *Astronomy Education Review, 8*(1).

Revell, A., & Wainwright, E. (2009). What makes lectures 'unmissable'? Insights into teaching excellence and active learning. *Journal of Geography in Higher Education, 33*(2), 209-223.

Rodgers, J. R. (2002). Encouraging tutorial attendance at university did not improve performance. *Australian Economic Papers, 41*(3), 255-266.

Romer, D. (1993). Do students go to class? Should they? *Journal of Economic Perspectives, 7*(3), 167-174.

Shannon, S. J. (2006, December). Why don't students attend lectures and what can be done about it through using iPod nanos? Paper presented at the *23rd ASCILITE Conference: Who's learning? Whose technology?* The University of Sydney, Australia. Retrieved from http://www.ascilite.org.au/conferences/ sydney06 //proceeding/pdf_papers/p28.pdf

Steers, R. M., & Rhodes, S. R. (1978). Major influences on employee attendance: A process model. *Journal of Applied Psychology, 63*(4), 391-407.

Trenholm, B., & Dunnett, J. (2007). When it all "clicks"—the effectiveness of using game show technology in the classroom. *Financial Education Association, Bermuda*. Retrieved from http://abeweb.org/proceedings/proceedings07/Bdunnett.pdf

van Schalkwyk, S., Menkveld, H., & Ruiters, J. (2010). What's the story with class attendance? First-year students: Statistics and perspectives. *South African Journal of Higher Education, 24*(4), 630-645.

Wood, D. M., Burke Da Silva, K. L., & Menz, R. I. (2007, July). *Are the benefits of clickers due to the enforcement of good pedagogy?* Paper presented at the 30th HERDSA Annual Conference, Adelaide, Australia. Retrieved from http://www.herdsa.org.au/wp-content/uploads conference/2007/papers/p179.pdf

The 2012 Paul T. Hiser Exemplary Publication Award Co-Recipients

John M. Ritz and P. Scott Bevins
"Economics, Innovations, Technology, and Engineering Education: The Connections"

and

Mary Annette Rose
"EnviroTech: Student Outcomes of an Interdisciplinary Project That Linked Technology and Environment"

The Board of Editors of The Journal of Technology Studies and the Board of Directors are pleased to announce the recipient of the Paul T. Hiser Exemplary Publication Award for Volume XXXVIII, 2012.

The Board of Directors established this award for deserving scholars. In recognition for his exemplary service to the profession and to the honorary as a Trustee and Director, the award bears Dr. Hiser's name. It is given to the author or authors of articles judged to be the best of those published each year in this journal.

Selection Process

Each member of the Editorial Board recommends the manuscript that he or she considers the best of those reviewed during the year. The board nominates articles based on their evaluation against specific criteria. A majority vote of the editors is required for the award to be made. The honor society's Board of Directors renders final approval of the process and the award.

Criteria

1. The subject matter of the manuscript must be clearly in the domain of one or more of the professions in technology.

2. The article should be exemplary in one or more of the following ways:
   - Ground-breaking philosophical thought.
   - Historical consequence in that it contains significant lessons for the present and the future.
   - Innovative research methodology and design.
   - Trends or issues that currently influence the field or are likely to affect it.
   - Unique yet probable solutions to current or future problems.

A $300 award recognizes the recipient(s) for the year and is presented during an Epsilon Pi Tau program at an annual professional association conference.

GUIDELINES FOR

The Journal of Technology Studies

A refereed publication of Epsilon Pi Tau the International Honor Society for Professions in Technology.

The Journal of Technology Studies (JOTS) is the flagship, peer-reviewed journal of Epsilon Pi Tau, an international honor society for technology professions. One printed volume per year is mailed to all active members of the society as well as to subscribing academic and general libraries around the globe. All issues (begining wih 1995 to the current year), both print and those published in electronic format, are available online at scholar.lib.vt.edu/ejournals/jots.

The journal is indexed in Current Index to Journals of Education, the International Bibliography of the Social Sciences, and by VOCED, the UNESCO/NCVER research database for technical and vocational education and training maintained by NCVER in Adelaide, Australia (www.voced.edu.au).

SUBJECT FOCUS

JOTS welcomes *original* manuscripts from scholars worldwide, focused on the depth and breadth of technology as practiced and understood past, present, and future. Epsilon Pi Tau, as perhaps the most comprehensive honor society among technology professions, seeks to provide up-to-date and insightful information to its increasingly diverse membership as well as the broader public. Authors need not be members of the society in order to submit manuscripts for consideration. Contributions from academe, government, and the private sector are equally welcome.

An overview of the breadth of topics of potential interest to our readers can be gained from the 17 subclasses within the "Technology" category in the Library of Congress classification scheme (http://www.loc.gov/catdir/cpso/lcco/lcco_t.pdf). Authors are strongly urged to peruse this list as they consider developing articles for journal consideration. In addition, JOTS is interested in manuscripts that provide:

- brief biographical portraits of leaders in technology that highlight the individuals' contributions made in dis tinct fields of technology or its wider appreciation within society,
- thoughtful reflections about technology practice,
- insights about personal transitions in technology from formal education to the work environment or vice versa,
- anthropology, economics, history, philosophy, and sociology of technology,
- technology within society and its relationship to other disciplines,
- technology policy at local, national, and international levels,
- comparative studies of technology development, implementation, and/or education,
- industrial research and development,or
- new and emerging technologies and technology's role in shaping the future.

The immense diversity of technology, along with its applications and import, requires that authors communicate clearly, concisely, and only semi-technically to readers from a diverse set of backgrounds. Authors may assume some technical background on the part of the reader but not in-depth knowledge of the particular technology that is the focus of the article. Highly technical articles on any field of technology are not within the purview of the journal. Articles whose focus has been extensively explored in prior issues of the Journal are of potential interest only if they (a) open up entirely new vistas on the topic, (b) provide significant new information or data that overturn or modify prior conceptions; or (c) engage substantially one or more previously published articles in a debate that is likely to interest and inform readers. Syntheses of developments within a given field of technology are welcome as are metanalyses of research regarding a particular technology, its applications, or the process of technical education and/or skill acquisition. Research studies should employ methodological procedures appropriate to the problem being addressed and must evince suitable design, execution, analysis, and conclusions. Surveys, for example, that exhibit any or all of the following characteristics are of no interest to the journal: (a) insufficient awareness of prior research on this topic, (b) insufficient sample size, (c) improper survey design, (d) inappropriate survey administration, (e) high mortality, (f) inadequate statistical analysis, and/or (g) conclusions not supported by either the data or the research design employed. The JOTS is neutral in regards to qualitative, quantitative, or mixed method approaches to research but insists on research of high quality.

GUIDELINES FOR
The Journal of Technology Studies
(Continued)

GUIDELINES FOR SUBMISSION

Articles must conform to the current edition of the *Publication Manual of the American Psychological Association*. All articles must be original, represent work of the named authors, not be under consideration elsewhere, and not be published elsewhere in English or any other language. Electronic submissions in either rich-text format or Microsoft Word formats are required. E-mail submissions should be sent to the editor at jots@bgsu.edu.

Manuscripts should be no more that 25 double- spaced and unjustified pages, including references. Abstracts are required and should be no longer than 250 words. Also required is a list of keywords from your paper in your abstract. To do this, indent as you would if you were starting a new paragraph, type *keywords*: (italicized), and then list your keywords. Listing keywords will help researchers find your work in databases.

Typescript should be 12 point *Times New Roman* or a close approximation. Only manuscripts in English that conform to American usage will be accepted. Figures, tables, photographs, and artwork must be of good quality and conform to the *Publication Manual of the American Psychological Association, specifically complying with the rules of Style® for* form, citation style, and copyright. The Journal of Technology Studies seeks to maintain the highest standards of academic integrity and asks all contributors to apply proper due diligence in manuscript preparation.

REVIEW PROCESS

Articles deemed worthy for consideration by the editor undergo anonymous peer review by members of the JOTS editorial board. Authors who submit an article that does not merit review by the editorial board are informed within approximately three weeks of receipt of the article so they may explore other publishing venues. A rejection may be based solely on the content focus of the article and not its intrinsic merit, particularly where the topic has been extensively explored in prior JOTS articles. Articles that exhibit extensive problems in expression, grammar, spelling, and/or APA format are summarily rejected. Authors of articles that have been peer-reviewed are informed within three months from the date of submission. Anonymous comments of reviewers are provided to authors who are invited to submit a revised article for either publication or a second round of review. The editor does not automatically provide reviewer comments to authors whose articles have been rejected via the peer review process. However, such feedback may be provided if the editor determines that the feedback might prove helpful to authors as they pursue other publishing opportunities.

PUBLICATION

Accepted articles are published in the on-line version of the journal (http://scholar.lib.vt.edu/ejournals/JOTS/) as the manuscript exits the layout and proofing process. Currently, JOTS articles also appear in a print issue at the beginning of the next calendar year. Authors co-retain rights to the published article along with Epsilon Pi Tau. When requested, the editor will supply information about an accepted article that has not yet appeared on-line or in print for faculty undergoing tenure review.