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# The Journal of Technology Studies

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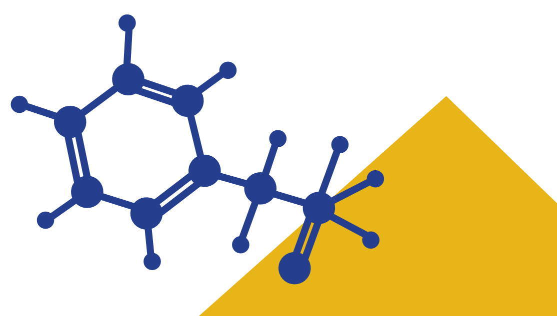

A refereed publication of Epsilon Pi Tau The International Honor Society for Professions in Technology.

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

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Volume XLI, Number 2, Fall 2015

# Evaluation of a Nuclear Energy Production Technology Program

By Kenneth W. Flowers and Richard Zinser

## ABSTRACT

This study investigated the perceptions held by key individuals within the energy industry involved in the development of an Energy Production Technology degree program at a Midwest community college to help address the need for qualified workers for the local nuclear power plants. Through open-ended interviews and surveys, the mixed methods case study collected data from 34 Energy Production Technology (EPT) program graduates, seven EPT program advisory committee members, and four employers of graduates in the energy industry. The findings revealed that the program was successful for creating a supply of qualified technicians; the employers and graduates equally believed that the program adequately prepared technicians for employment. Lessons learned include having a realistic labor projection and knowledge of employability requirements, and making sure all the right stakeholders are involved in the program development process. The study has implications for policy and practice in career and technical education, especially for those who work closely with industry.

*Key words: energy industry training, program evaluation, community college*

## PROJECT BACKGROUND

According to the Nuclear Energy Institute (NEI) over one-third of the current workforce in the industry may be retiring within the next five years, which will require training and hiring about 25,000 new workers (NEI, 2010). To address the projected shortage of energy industry professionals for the region it serves, the community college in this study, through a partnership with the local energy industry, developed an Energy Production Technology degree program to give local individuals looking for employment the opportunity to prepare for high-skilled, high-wage jobs in the energy field. Due to feedback from local energy employers, the community college was sought out, because, historically, the commercial nuclear industry counted on the U.S. Navy to provide technicians for civilian jobs, but the size of this group has decreased over the years while the demand has increased.

This program was developed in part by following the curriculum outline that was established by the Nuclear Uniform Curriculum Program (NUCP) created in 2007 by NEI. The NUCP was created as a quasi-accreditation process to guide community colleges to help power plants staff their future workforce, and it is a standardized program for educating operators and technicians for jobs at nuclear plants (NEI, 2010). Based on a review of the literature, prior to 2007, there is little evidence of a concerted effort between nuclear power plants and community colleges to engage in such a partnership. The NUCP program requires a common curriculum regarding plant equipment and systems, science and mathematics, and technical electives in a student's chosen focus area (chemistry, operations, health, physics, radiation protection, and maintenance).

Regardless of NEI involvement, prior to the development of an energy-focused program, one of the concerns often unfamiliar to any college that attempts to develop such a degree program is that the power production industry is highly regulated. According to Laraia and Dlouhy (1999), "the laws and regulations are often complex and overlapping, involving several government ministries, departments, and/or agencies. These laws and regulations typically provide licensing of various aspects of the nuclear industry, government oversight, setting of standards (both technical and environmental), and protection of human health from radiological (and other) hazards" (p. 40). Safety is a preeminent concern in the nuclear industry, not only for its own sake, but also because of its sensitivity in terms of public perception and, formally, because of national and regional regulations and international agreements (Organisation for Economic Cooperation and Development [OECD], 2012). Local Energy partners supported this, by characterizing the importance of a high level of education and training to maintain the level of safety necessary for the plants to run successfully.

## RATIONALE FOR THE STUDY

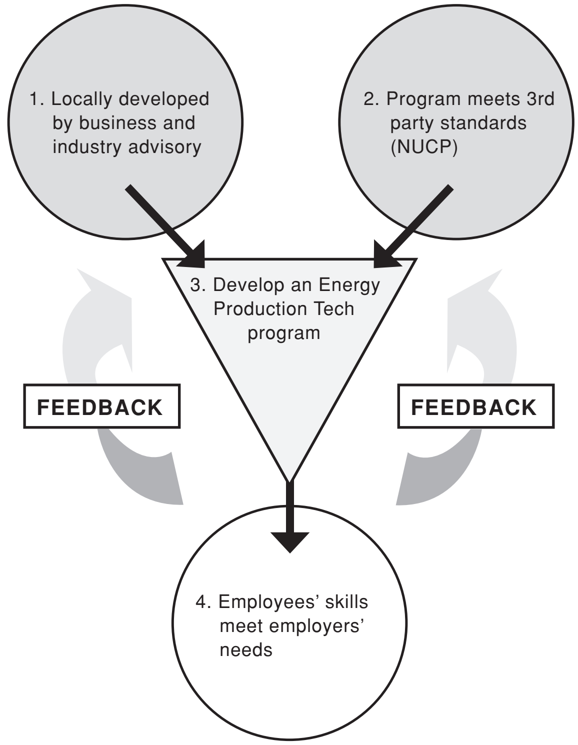
The purpose of this research was to determine the perceived success of the new Energy Production Technology program created in partnership with a community college and its local business and industry service district. It was essential to assess the feedback process within this partnership to determine if the program was yielding effective results as perceived by program graduates and their employers. Equally important was to determine the role played by the advisory committee that was developed to implement and provide oversight to the program.

A principal goal of community colleges is to ensure that the workers in the region they serve have the educational tools needed to survive in today's job market (Government Accountability Office, 2008). In order for any degree program to remain viable and relevant, it must prepare highly skilled individuals who are aligned with the changing needs of a given industry. To do this, the labor force and educational organizations should be structured around integrated education, training, and program evaluation processes (Government Accountability Office, 2008). For employers, this extended effort provides opportunities for recruiting and training new employees, additional skills for incumbents, and potentially improving retention.

Assessing the success of a program is vital to provide the best service to stakeholders. According to Epstein, Coates, Wray, and Swain (2006), "The stakeholder's role is broader than being a customer of services, because the conditions citizens experience in the community and in their lives are affected by many things other than community services" (p. 27). Success depends entirely on how community colleges, along with their region's stakeholders, can effectively collaborate and bring collective resources to bear on the challenges facing them. Yet there is little published research on the evaluation of technical programs at this level (Zinser, 2003).

## CONCEPTUAL FRAMEWORK

As graduates become employed in the industry, it is important to evaluate the validity of the training that is provided by the college. A continual feedback loop of evaluation and improvement should be developed as both the college and industry review and adjust perceived curriculum and employment outcome gaps.




***Locally Developed by Businessand Industry Advisory Committee***

When developing a new program at any college, there must be coordination across key state, local, and stakeholder agencies. According to a report by MPR Associates (2010), "Development of programs of study includes analysis of current labor market information to determine which programs of study will truly result in high demand jobs, input from stakeholders that is genuine and sustained, and funds dedicated to both initial development of POS as well as sustenance through curriculum development and business and education input" (p. 15). Once these pertinent data are collected and reviewed, if validated, local business and industry partners in the community convene to form a program advisory committee to cultivate the program.

***Program Meets Third Party Standards (NUCP)***

A key benefit of the NUCP is that once graduates who earn this certificate are hired at the plant, they can be waived or exempted from portions of required initial training. By evaluating and accrediting the community college training programs, this waiving or exemption of training is a cost-saving measure for the power plants allowing the plants to then redirect those financial resources to other areas. Organizing industry partnerships with two-year education programs helps leverage resources to provide the next generation of highly skilled workers (NEI, 2010).

***Develop an Energy Production Technology Program***

The strengths of the program developed by the internal analysis included strong support from the local power generation industry, industry-experienced adjunct instructors, strong base of potential workers due to manufacturing shortages, NEI pilot program, and strong government (and public) support for renewable energy. These strengths support the framework focus centered around the advisory committee (strong support from local industry), third-party program review process (NEI pilot) program, and adequately prepared employees (strong base of potential workers).

***Employees' Skills Meet Employers' Needs***

One of the key intents of the Energy Production Technology program is to prepare students to enter the workforce in an energy production area while also increasing the skills of those already in the workforce. In order to continue to meet these employer needs, as the program matures, it is important to sustain a feedback continuum in order to maintain program relevancy. For example, at the early stages of program development, based on feedback from employers and students, a key component missing from the program that limited students' preparedness was that the college did not have lab equipment or a recognized lab space for one of the hands-on technical programs. Gaps were identified through instructor and student surveys that revealed this limited access to equipment. Initially, to use appropriate equipment, instructors would either schedule time at the plant or bring pieces to the class for students to use. This, at times, caused logistical issues for both students and the instructors.

## METHODS AND PROCEDURES

Three research questions formed the basis for this study to examine issues surrounding the Energy Production Technology program. The intent was to: (1) determine the perceptions of the advisory committee participants regarding their role with the program including questions about curriculum, equipment, facilities, and job placement; (2) understand the perceptions of employers regarding how the college program prepared students for employment in the energy field; and (3) ascertain program graduates' perceptions about how the college program readied them for employment in the energy field and to provide a reflection of their scholastic experience at the college.

This research used a mixed method, case study approach as the strategy of inquiry. Characterized by its exploratory nature, this type of research seeks a more in-depth, detailed, and close-up view of a topic, collecting data with questions that typically begin with "how" or "what" (Creswell, 1998) and expressing data using words rather than numbers. The method provides opportunities to interact with subjects on a human-to-human basis, to explore further, if necessary, using follow-up questions, and to arrive at conclusions post hoc rather than a priori (Creswell, 1998; Lancy, 1993). Additionally, online surveys were used to understand the perceptions of the program graduates. Data was analyzed and organized into themes and patterns consistent with the conceptual framework.

***Selection of Subjects***

Purposeful sampling is a technique widely used in mixed methods research for the identification and selection of information-rich cases for the most effective use of limited resources (Patton 2002). This involves identifying and selecting individuals or groups of individuals who are especially knowledgeable about, or experienced with, a phenomenon of interest (Creswell & Plano Clark, 2010). The population in the study included individuals (students, advisory committee members, and energy employers) who were currently participating in, or who had recently participated in, the college's EPT program, as noted below:

> **Group One:** Former and current advisory committee members (2008-present) who helped establish and continue oversight of the program. (N = 7; interview)
>
> **Group Two:** Energy production employers who have hired graduates from the program. (N = 4; interview, skills checklist)
>
> **Group Three:** Students who had graduated from the EPT during the life of the program (2008-present). (N = 34; survey)

Personal interviews were conducted with group one, the seven individuals who had or still continue to participate in the advisory committee, to capture their perceptions of the program development and implementation. To address research question number one, advisory committee participants were asked their perceptions regarding their role with the program, including questions about curriculum, equipment, facilities, and job placement.

Personal interviews were also conducted with group two, the four individuals at the power plants who have hired graduates from the college's energy program. To address research question number two, these participants were asked their perceptions about how the college program prepared students for employment in the energy field. Included as part of the interview process, these individuals were also asked to complete a skills checklist that examined the specific skill sets of the graduates they have hired.

An online survey was developed to understand the perceptions of the students who graduated from the program (group three). To address research question number three, program participants were asked their perceptions about how the college program readied them for employment in the energy field and to provide a reflection of their scholastic experience at the college. Based on graduation data received from college records, 125 potential program graduates were available for the survey. An email request was sent out, as well as follow-up reminders, which yielded 34 participants out of 115 (10 addresses were undeliverable) for a 30% response rate. Descriptive statistics were used to summarize and analyze the survey data.

Once all data was sorted and reviewed, patterns began to materialize. A theme such as "nuclear culture" for example, was created to facilitate additional layers of complex analysis. The interpretation of data also required a basic understanding of human behavior as it was important to interpret each individual's explanation. Additional analysis was completed in order to have the interview evidence validated. "In qualitative research, validation has focused on assessing how well participants' meanings have been captured and interpreted" (Ritchie & Lewis, 2013, p. 358). This method is known as respondent validation (or member checking), which involved returning to the study participants of both Groups One and Two and asking them to validate the analyses (Burnard, Gill, Stewart, Treasure, & Chadwick, 2008, para. 19). The interview subjects were provided transcripts of the interview and asked to review the account as deduced by the researcher, to make sure their narrative was accurately applied.

## FINDINGS

While reviewing the interview transcripts, common statements or expressions that appeared to be connected to the research questions were highlighted, coded, and grouped into themes using the reduction process. For example, statements that were coded as "developing a local hiring pool" were grouped with other significant topics coded as "lack of trained individuals," "entry-level candidates," and "looking for employable people" into a larger theme coded as "creating a qualified workforce." Each significant point from the transcripts of the employers and the advisory committee were coded using a similar framework as the example listed above. Through the raw data collected from the employers three themes emerged, whereas the advisory committee interviews fostered four themes. In reporting the findings, names and other identifying factors of the subjects have been restricted; if a name was needed to improve readability, a pseudonym or alias was used.

### *Research Question One*

During the interview process, study participants were asked to reflect on their experiences as an advisory committee member, why they felt it was important to participate in the program, describe the NUCP feedback loop, describe the impact to the workforce, provide lessons learned and reflect on significant experiences. Analysis of the interview data provided dominant themes that participants viewed as significant factors regarding their participation in the program's advisory committee as described below.

**Theme one: Program has created qualified workers.** Based on the perspective of developing competent workers coupled with the perceptions of mass retirements, the advisory committee commented favorably that the college did indeed offer a supply of qualified technicians with at least 45 of the 125 program graduates presently employed in the local energy industry. According to Stanley (subject 2, personal interview, July 6, 2015), a college representative, "I think it's been huge. I mean look at the number of graduates who are working at the local plants . . . before this program, we had nothing."

**Theme two: Be sure to involve the right stakeholders.** Despite getting key stakeholders on the advisory board, not having the right person from all levels within the industry did impact the effectiveness of the feedback loop for the NUCP process among the committee, employer, and student. Mark (subject 3, personal interview, July 7, 2015) for example stated that, "Feedback wise, to be honest, I really wish we would add more stake from a management level... it seemed like there was a lot of in-between that lacked getting information from a real stakeholder." In other words, based on this feedback, because of the lack of stakeholder involvement regarding student results, some outcomes were not addressed, and it sometimes hurt the reputation of the program.

**Theme three: Program not adequately preparing graduates to pass the pre-employment test.** The nuclear energy industry utilizes pre-employment testing on certain jobs to identify and assess a candidate's abilities and skills. When the program was first developed, the concept of pre-employment testing was not an issue strongly discussed by the advisory committee--it was an afterthought. Also, students were vaguely aware of the process, and the curriculum was not developed so they could easily transition into successful pre-employment exams; therefore, many students were not prepared for such tests. This was a consistent concern among all three groups (students, employers, and advisory committee). Larry (subject 1, personal interview, July 1, 2015) felt quite strongly regarding this as he stated that, "The biggest gap that I saw for the entire time I was there, and I would be surprised if it's not still a gap today, was the mathematics to prepare the students for the MASS/POSS test" (the pre-employment exam).

**Theme four: Need a better understanding of balance between labor supply and demand.** During the development process the college faced significant challenges to help "create a market"—that is, to not simply harvest a supply of degrees, but to also influence the demand for those degrees. Another concern was that "labor demand" included some positions that did not require a degree and therefore inflated the plants' estimates of the number of new hires needed. Founded on the lack of a more in-depth environmental scan and needs analysis, it was better understood that it was probably irresponsible to let the program increase to 230 students. Larry (pseudonym) suggested that:

> My biggest advice is to watch your numbers. We kind of were told that by some people up front. In retrospect we probably should pay more attention to that. Watch the numbers based on the demand in the local community and basically put a cap on the number of people that are in the program.

Based on the disappointment from those that could not find employment in the industry, making sure to have the right balance of labor supply and demand is critical.

***Research Question Two***

During the interview process, employers who hired the graduates were asked to reflect on whether the EPT program prepared students for a career in the energy industry, how they compared to other school's graduates, what skills they were best or least equipped with, and what additional advice they could provide to the college to help strengthen the program. Analysis of the interview data provided dominant themes that participants viewed as significant factors regarding the college's program preparing students for employment in the energy field.

**Theme one: Students are well prepared on core technical skills.** Based on both the interview responses and the replies to the skills checklist, employers from each plant agreed that EPT graduates have the core technical skills necessary to work in the energy industry. Evan (subject 4, personal interview, July 30, 2015) from Plant A stated, "They're good at what they do. They came into the training class here from the courses and I think that gave them a good leg-up for the next level. The plant specific, system specific things."

**Theme two: Individuals from the military are better prepared.** When asked how EPT graduates from the college compare to those graduates from other technical programs (military other colleges), all respondents collectively stated that the people in the military had an advantage. A key theme that should be pointed out from these statements is that "it isn't because of the schooling," it is ingrained in the military recruits because it has been their job.

**Theme three: The program should better prepare students for the "nuclear culture."**
In Table 1 of the skills checklist response, employers of EPT graduates moderately agreed that graduates were prepared. However, what the skills checklist did not identify that what the interviews included was the concept of preparedness for an employee in the nuclear field. When asked about some shortcomings of EPT graduates, Evan (pseudonym) stated," Probably just the difference in our industry and how we do business. We have very strict guidelines on how to work through [any] procedure" (in the nuclear environment).

Employers filled out a skills' checklist based on a review of the program's guidelines regarding the students' preparedness. Tables 1-3 display the respondents' answers to questions regarding graduates' skills preparedness, core fundamentals preparedness, and overall preparedness. The total mean scores in Table 1 ranged from 4.50 – 5.50. Overall the employers moderately agreed that the graduates had the necessary core skills. It should be noted that the lower standard deviation (SD) would generally mean that there was significant alignment among the respondents' answers; however, the small number of individuals interviewed (n = 4) drastically affects the confidence interval of this data.

The mean scores for Nuclear Uniform Curriculum Program (NUCP) core fundamentals preparedness (see Table 2) were above the mid-point, with a range of 4.00 – 5.25. The highest skill score was "Computers (plant specific)," and the lowest was a tie among three topics: "Electrical Sciences," "Heat Transfer and Fluid Flow" and "Chemistry." All four supervisors scored these topics equally.

On the skills checklist, question 3 asked about overall preparedness. The total mean score on this topic was 5.25, which indicates moderate agreement (Table 3).

To summarize the responses to research question number 2, overall the four employer respondents believed that graduates of an Energy Production Technology program were prepared for employment. They did believe the graduates could use some work being prepared for the nuclear culture, an area in which they believed military recruits had an obvious advantage.

***Research Question Three***
The third research question sought perceptions from the energy program's graduates regarding how the college program readied them for employment in the energy field, and to provide a reflection of their scholastic experience at the college. A survey tool based on a review of program guidelines was used to gather

**Table 1:** *Employers' Perceptions of Graduate Skills Preparedness*

| Question | Disagree Strongly n (%) | Disagree Moderately n (%) | Disagree Slightly n (%) | Agree Slightly n (%) | Agree Moderately n(%) | Agree Strongly n (%) | Mean | SD |
|---|---|---|---|---|---|---|---|---|
| Overall, program prepared graduates hired for these job skills: | | | | | | | | |
| Successfully demonstrate safe work habits | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 4(100.0) | 0(0.0) | 5.00 | 0.00 |
| Successfully work in teams | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 2(50.0) | 2(50.0) | 5.50 | 0.50 |
| Successfully work independently | 0(0.0) | 0(0.0) | 0(0.0) | 1(25.0) | 2(50.0) | 1(25.0) | 5.00 | 0.71 |
| Successfully solve complex problems | 0(0.0) | 0(0.0) | 0(0.0) | 2(50.0) | 2(50.0) | 0(0.0) | 4.50 | 0.50 |
| Document clearly and effectively | 0(0.0) | 0(0.0) | 0(0.0) | 2(50.0) | 2(50.0) | 0(0.0) | 4.50 | 0.50 |
| Communicate clearly and effectively | 0(0.0) | 0(0.0) | 0(0.0) | 1(25.0) | 2(50.0) | 1(25.0) | 5.00 | 0.71 |

*Note.* Likert Scale = Disagree Strongly (1), Disagree Moderately (2), Disagree Slightly (3), Agree Slightly (4), Agree Moderately (5), Agree Strongly (6).

**Table 2:** *Employers' Perceptions of Nuclear Uniform Curriculum Program (NUCP) Core Fundamentals Preparedness*

| Question | Disagree Strongly n (%) | Disagree Moderately n (%) | Disagree Slightly n (%) | Agree Slightly n (%) | Agree Moderately n(%) | Agree Strongly n (%) | Mean | SD |
|---|---|---|---|---|---|---|---|---|
| Overall, program successfully prepared graduates with these NUCP core fundamentals: | | | | | | | | |
| Mathematics | 0(0.0) | 0(0.0) | 0(0.0) | 1(25.0) | 3(75.0) | 0(0.0) | 4.75 | 0.43 |
| Physics | 0(0.0) | 0(0.0) | 0(0.0) | 3(75.0) | 1(25.0) | 0(0.0) | 4.25 | 0.43 |
| Electrical Sciences | 0(0.0) | 0(0.0) | 0(0.0) | 4(100.0) | 0(0.0) | 0(0.0) | 4.00 | 0.00 |
| Basic Atomic and Nuclear Physics | 0(0.0) | 0(0.0) | 0(0.0) | 2(50.0) | 2(50.0) | 0(0.0) | 4.50 | 0.50 |
| Heat Transfer and Fluid Flow | 0(0.0) | 0(0.0) | 0(0.0) | 4(100.0) | 0(0.0) | 0(0.0) | 4.00 | 0.00 |
| Chemistry | 0(0.0) | 0(0.0) | 0(0.0) | 4(100.0) | 0(0.0) | 0(0.0) | 4.00 | 0.00 |
| Properties of Reactor Plant Materials | 0(0.0) | 0(0.0) | 0(0.0) | 3(75.0) | 1(25.0) | 0(0.0) | 4.25 | 0.43 |
| Radiation Detection and Protection | 0(0.0) | 0(0.0) | 0(0.0) | 1(25.0) | 3(75.0) | 0(0.0) | 4.75 | 0.43 |
| Reactor Plant Protection and Safety | 0(0.0) | 0(0.0) | 0(0.0) | 2(50.0) | 2(50.0) | 0(0.0) | 4.50 | 0.50 |
| Computers (Plant Specific) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 3(75.0) | 1(25.0) | 5.25 | 0.43 |
| Basic Systems Knowledge | 0(0.0) | 0(0.0) | 0(0.0) | 2(50.0) | 2(50.0) | 0(0.0) | 4.50 | 0.50 |
| Basic Components Knowledge | 0(0.0) | 0(0.0) | 0(0.0) | 2(50.0) | 2(50.0) | 0(0.0) | 4.50 | 0.50 |

*Note.* Likert Scale = Disagree Strongly (1), Disagree Moderately (2), Disagree Slightly (3), Agree Slightly (4), Agree Moderately (5), Agree Strongly (6).

**Table 3:** *Employers' Perceptions of Students' Overall Preparedness*

| Question | Disagree Strongly n (%) | Disagree Moderately n (%) | Disagree Slightly n (%) | Agree Slightly n (%) | Agree Moderately n(%) | Agree Strongly n (%) | Mean | SD |
|---|---|---|---|---|---|---|---|---|
| Overall, the Energy Production Technology Program has: | | | | | | | | |
| Successfully prepared the graduates I have hired for a career in the energy industry | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 3(75.0) | 1(25.0) | 5.25 | 0.43 |

*Note.* Likert Scale = Disagree Strongly (1), Disagree Moderately (2), Disagree Slightly (3), Agree Slightly (4), Agree Moderately (5), Agree Strongly (6).

**Table 4:** *Students' Perceptions of Instructional Content and Program Quality*

| Question 3 | Employed Y or N | Disagree Strongly n (%) | Disagree Moderately n (%) | Disagree Slightly n (%) | Agree Slightly n (%) | Agree Moderately n(%) | Agree Strongly n (%) | Mean | SD |
|---|---|---|---|---|---|---|---|---|---|
| Instructional content and quality program were to provide me with strong practical job application experience. | | | | | | | | | |
| | Yes (n=18) | 0(0.0) | 1(5.5) | 1(5.5) | 0(0.0) | 8(44.4) | 8(44.4) | 5.17 | 1.07 |
| | No (n=16) | 2(12.5) | 1(6.3) | 2(12.5) | 1(6.3) | 8(50.0) | 2(12.5) | 4.13 | 1.58 |
| | Tot. (n=34) | 2(5.9) | 2(5.9) | 3(8.8) | 1(2.9) | 16(47.1) | 10(29.4) | 4.68 | 1.43 |

*Note.* Likert Scale = Disagree Strongly (1), Disagree Moderately (2), Disagree Slightly (3), Agree Slightly (4), Agree Moderately (5), Agree Strongly (6).

**Table 5:** *Students' Perceptions of Job Skills Preparedness*

| Question 3 | Employed Y or N | Disagree Strongly n (%) | Disagree Moderately n (%) | Disagree Slightly n (%) | Agree Slightly n (%) | Agree Moderately n(%) | Agree Strongly n (%) | Mean | SD |
|---|---|---|---|---|---|---|---|---|---|
| Overall, program prepared me for the job skills: | | | | | | | | | |
| Successfully demonstrate safe work habits | Yes (n=18) | 0(0.0) | 0(0.0) | 2(11.1) | 5(27.8) | 4(22.2) | 7(38.9) | 4.89 | 1.05 |
| | No (n=16) | 0(0.0) | 0(0.0) | 2(12.5) | 3(18.8) | 4(25.0) | 7(43.8) | 5.00 | 1.06 |
| | Tot. (n=34) | 0(0.0) | 0(0.0) | 4(11.8) | 8(23.5) | 8(23.5) | 14(41.5) | 4.94 | 1.06 |
| Successfully work in teams | Yes (n=18) | 0(0.0) | 0(0.0) | 1(5.6) | 3(16.7) | 3(16.8) | 11(68.8) | 5.33 | 0.94 |
| | No (n=16) | 0(0.0) | 0(0.0) | 3(18.8) | 2(12.5) | 4(25.0) | 7(43.8) | 4.94 | 1.14 |
| | Tot. (n=34) | 0(0.0) | 0(0.0) | 4(11.8) | 5(14.7) | 7(20.6) | 18(52.9) | 5.15 | 1.06 |
| Successfully work independently | Yes (n=18) | 0(0.0) | 0(0.0) | 1(5.6) | 3(16.7) | 5(31.3) | 9(56.3) | 5.22 | 0.92 |
| | No (n=16) | 0(0.0) | 0(0.0) | 3(18.8) | 2(12.5) | 4(25.0) | 7(43.8) | 4.94 | 1.14 |
| | Tot. (n=34) | 0(0.0) | 0(0.0) | 4(11.8) | 5(14.7) | 9(26.5) | 16(47.1) | 5.09 | 1.04 |
| Successfully solve complex problems | Yes (n=18) | 0(0.0) | 0(0.0) | 1(5.6) | 4(22.2) | 5(27.8) | 8(44.4) | 5.11 | 0.94 |
| | No (n=16) | 1(6.3) | 0(0.0) | 2(12.5) | 2(12.5) | 4(25.0) | 7(43.8) | 4.81 | 1.42 |
| | Tot. (n=34) | 1(2.9) | 0(0.0) | 3(8.8) | 6(17.7) | 9(26.5) | 15(44.1) | 4.97 | 1.20 |
| Document clearly and effectively | Yes (n=18) | 0(0.0) | 0(0.0) | 2(11.1) | 3(16.8) | 6(33.3) | 7(38.9) | 5.00 | 1.00 |
| | No (n=16) | 1(6.3) | 1(6.3) | 2(12.5) | 1(6.25) | 4(25.0) | 7(43.8) | 4.69 | 1.57 |
| | Tot. (n=34) | 1(2.9) | 1(2.9) | 4(11.8) | 4(11.8) | 10(29.4) | 14(41.1) | 4.85 | 1.31 |
| Communicate clearly and effectively | Yes (n=18) | 0(0.0) | 1(5.6) | 1(5.6) | 2(11.1) | 7(38.9) | 7(38.9) | 5.00 | 1.11 |
| | No (n=16) | 1(6.3) | 0(0.0) | 2(12.5) | 2(12.5) | 3(18.8) | 8(50.0) | 4.88 | 1.45 |
| | Tot. (n=34) | 1(2.9) | 1(2.9) | 3(8.8) | 4(11.8) | 10(29.4) | 15(44.1) | 4.94 | 1.28 |

*Note.* Likert Scale = Disagree Strongly (1), Disagree Moderately (2), Disagree Slightly (3), Agree Slightly (4), Agree Moderately (5), Agree Strongly (6).

information about graduates' perceptions both in school and if applicable, at subsequent employment, regarding if they believed they were prepared for employment. It was important to investigate what this new program's experience meant to the participants, and to determine what they believed to be the strengths and weaknesses of the program, based on both their perceptions of their experience and ability to be employed. The survey was comprised of 20 questions using a six-point Likert scale, and it included three open-ended questions regarding their perceptions of the program.

For question 3 of the survey, respondents were asked about *instructional content and program quality.* The results presented in Table 4, are broken down by those employed in the industry, those not employed in the industry, and the overall total.

The total mean score regarding instructional content and program quality was moderately high at 4.68. Over 78% of the students moderately agreed that the curriculum was designed to provide them with strong, practical job application experience. This number is based on an average that included students who stated they were working in the energy industry and those who were not. For students with jobs (N = 18) in the energy field, 89% of them felt the program content and quality was solid, whereas for students without such jobs (N = 16) 69% agreed. It is important to note that a pattern was revealed throughout this survey that the mean scores from students who did not attain a position in the energy field was much lower on average than students who did gain a position, and this lowers the total mean substantially. The mean scores regarding instructional content and program quality came in at 5.71 for student with jobs in the energy field and 4.13 for students who did not gain employment in this field. However the sample size is not large enough to establish statistical significance.

The mean scores regarding job skills preparedness in Table 5 were quite high with a range of 4.85 – 5.15. The highest skill score was "successfully work in teams" and the lowest was "document clearly and effectively": all other statements had a mean score over 4.8. More than 87% of the students felt that they had the appropriate job skills to work in the energy field. Significantly, even the students who did not have jobs in the energy field still felt very prepared by the program to work in energy by an average of 81%.

The mean scores for Nuclear Uniform Curriculum Program (NUCP) core fundamentals preparedness were above average with a range of 4.26 – 5.44. The highest skill score was "properties of reactor plant materials," and the lowest was

**Table 6:** *Perceptions of Nuclear Uniform Curriculum Program (NUCP) Core Fundamentals Preparedness*

| Question 3 | Employed Y or N | Disagree Strongly n (%) | Disagree Moderately n (%) | Disagree Slightly n (%) | Agree Slightly n (%) | Agree Moderately n(%) | Agree Strongly n (%) | Mean | SD |
|---|---|---|---|---|---|---|---|---|---|
| Overall, program prepared me to meet these Nuclear Uniform Curriculum Program (NUCP) core fundamentals: | | | | | | | | | |
| Mathematics | Yes (n=18) | 0(0.0) | 0(0.0) | 1(5.9) | 1(5.9) | 6(33.3) | 9(50.0) | 5.28 | 0.87 |
| | No (n=16) | 1(6.3) | 1(6.3) | 2(12.5) | 2(12.5) | 6(37.5) | 4(25.0) | 4.44 | 1.46 |
| | Tot. (n=34) | 1(2.9) | 1(2.9) | 3(8.8) | 3(11.8) | 12(35.3) | 13(38.2) | 4.88 | 1.25 |
| Physics | Yes (n=18) | 0(0.0) | 0(0.0) | 0(0.0) | 4(22.2) | 4(22.2 | 10(55.6) | 5.33 | .082 |
| | No (n=16) | 0(0.0) | 2(12.5) | 1(6.3) | 3(18.8) | 6(37.5) | 4(25.0) | 4.56 | 1.27 |
| | Tot. (n=34) | 0(0.0) | 2(5.9) | 1(2.9) | 7(20.6) | 10(29.4) | 14(41.2) | 4.97 | 1.12 |
| Electrical Sciences | Yes (n=18) | 0(0.0) | 0(0.0) | 1(5.56) | 4(22.2) | 6(33.3) | 7(38.4) | 5.06 | 0.91 |
| | No (n=16) | 1(6.3) | 2(12.5) | 0(0.0) | 5(31.3) | 4(25.0) | 4(25.0) | 4.31 | 1.49 |
| | Tot. (n=34) | 1(2.9) | 2(5.9) | 1(2.9) | 9(20.6) | 10(29.4) | 11(41.2) | 4.71 | 1.27 |

*Note.* Likert Scale = Disagree Strongly (1), Disagree Moderately (2), Disagree Slightly (3), Agree Slightly (4), Agree Moderately (5), Agree Strongly (6).

**Table 6 continued:** *Perceptions of Nuclear Uniform Curriculum Program (NUCP) Core Fundamentals Preparedness*

| Question 3 | Employed Y or N | Disagree Strongly n (%) | Disagree Moderately n (%) | Disagree Slightly n (%) | Agree Slightly n (%) | Agree Moderately n(%) | Agree Strongly n (%) | Mean | SD |
|---|---|---|---|---|---|---|---|---|---|
| Overall, program prepared me to meet these Nuclear Uniform Curriculum Program (NUCP) core fundamentals: | | | | | | | | | |
| Basic Atomic and Nuclear Physics | Yes (n=18) | 0(0.0) | 0(0.0) | 0(0.0) | 3(16.7) | 3(16.7) | 12(66.7) | 5.50 | .076 |
| | No (n=16) | 1(6.3) | 0(0.0) | 1(6.3) | 2(12.5) | 6(37.5) | 6(37.5) | 4.88 | 1.32 |
| | Tot. (n=34) | 1(2.9) | 0(0.0) | 1(2.9) | 5(14.7) | 9(29.4) | 18(51.5) | 5.21 | 1.11 |
| Heat Transfer and Fluid Flow | Yes (n=18) | 1(5.6) | 0(0.0) | 0(0.0) | 4(22.2) | 6(33.3) | 7(38.4) | 4.94 | 1.23 |
| | No (n=16) | 2(12.5) | 0(0.0) | 0(0.0) | 3(18.8) | 7(43.8) | 4(25.0) | 4.56 | 1.50 |
| | Tot. (n=34) | 3(8.8) | 0(0.0) | 0(0.0) | 7(20.6) | 13(38.2) | 11(32.4) | 4.76 | 1.37 |
| Chemistry | Yes (n=18) | 0(0.0) | 0(0.0) | 0(0.0) | 5(27.8) | 4(22.2) | 9(50.0) | 5.22 | 0.85 |
| | No (n=16) | 3(18.8) | 1(6.3) | 2(12.5) | 2(6.3) | 6(37.5) | 2(12.5) | 3.81 | 1.70 |
| | Tot. (n=34) | 3(8.8) | 1(2.9) | 2(5.9) | 7(20.6) | 10(29.4) | 11(32.4) | 4.56 | 1.50 |
| Properties of Reactor Plant Materials | Yes (n=18) | 0(0.0) | 0(0.0) | 0(0.0) | 2(11.1) | 2(11.1) | 14(77.9) | 5.67 | 0.67 |
| | No (n=16) | 0(0.0) | 1(6.3) | 0(0.0) | 2(12.5) | 5(31.3) | 8(50.0) | 5.19 | 1.07 |
| | Tot. (n=34) | 0(0.0) | 1(2.9) | 0(0.0) | 4(11.8) | 7(20.6) | 22(64.7) | 5.44 | 0.91 |
| Radiation Detection and Protection | Yes (n=18) | 0(0.0) | 0(0.0) | 2(11.1) | 4(22.2) | 2(11.1) | 10(55.6) | 5.11 | 1.10 |
| | No (n=16) | 1(6.3) | 0(0.0) | 0(0.0) | 3(18.8) | 5(31.3) | 7(43.8) | 5.00 | 1.27 |
| | Tot. (n=34) | 1(2.9) | 0(0.0) | 2(5.9) | 7(20.6) | 7(20.6) | 17(50.0) | 5.06 | 1.19 |
| Reactor Plant Protection and Safety | Yes (n=18) | 0(0.0) | 1(5.6) | 0(0.0) | 3(16.7) | 3(16.7) | 11(61.1) | 5.28 | 1.10 |
| | No (n=16) | 0(0.0) | 1(6.3) | 1(6.3) | 0(0.0) | 5(31.3) | 9(56.3) | 5.25 | 1.15 |
| | Tot. (n=34) | 0(0.0) | 2(5.9) | 1(2.9) | 3(8.8) | 8(23.5) | 20(58.8) | 5.26 | 1.12 |
| Computers (plant specific) | Yes (n=18) | 0(0.0) | 0(0.0) | 3(16.7) | 6(33.3) | 5(27.8) | 4(22.2) | 4.56 | 1.01 |
| | No (n=16) | 1(6.3) | 3(18.8) | 2(12.5) | 3(18.8) | 4(25.0) | 3(18.8) | 3.94 | 1.56 |
| | Tot. (n=34) | 1(2.9) | 3(8.8) | 5(14.7) | 9(26.5) | 9(26.5) | 7(24.2) | 4.26 | 1.34 |
| Basic Systems Knowledge | Yes (n=18) | 0(0.0) | 1(5.6) | 0(0.0) | 1(5,6) | 4(22.2) | 12(66.7) | 5.44 | 1.01 |
| | No (n=16) | 0(0.0) | 0(0.0) | 0(0.0) | 2(2.9) | 9(56.5) | 5(31.3) | 5.19 | 0.63 |
| | Tot. (n=34) | 0(0.0) | 1(2.9) | 0(0.0) | 3(8.8) | 13(38.2) | 17(50.0) | 5.32 | .087 |
| Basic Components Knowledge | Yes (n=18) | 0(0.0) | 0(0.0) | 2(11.1) | 1(5.6) | 4(22.2) | 11(61.1) | 5.33 | 1.00 |
| | No (n=16) | 0(0.0) | 0(0.0) | 0(0.0) | 2(12.5) | 8(50.0) | 6(37.5) | 5.25 | .066 |
| | Tot. (n=34) | 0(0.0) | 0(0.0) | 2(5.9) | 3(8.8) | 12(35.3) | 17(47.1) | 5.29 | .086 |

*Note.* Likert Scale = Disagree Strongly (1), Disagree Moderately (2), Disagree Slightly (3), Agree Slightly (4), Agree Moderately (5), Agree Strongly (6).

Table 7:

| Question | Mean | SD |
|---|---|---|
| Teaching methods, procedures, and course content program were: | | |
| A. very pertinent to my major. | 4.32 | 0.79 |
| B. very current and meaningful to me. | 4.18 | 0.95 |
| Related and support courses were: | | |
| A. very pertinent to my major. | 4.74 | 1.01 |
| B. very current and meaningful to me. | 4.65 | 1.16 |
| The work experience aspect of the program was: | | |
| A. readily available at convenient locations. | 4.18 | 1.84 |
| B. readily available at convenient times of day. | 4.18 | 1.75 |
| Career planning information provided by college: | | |
| A. successfully met my needs and interests. | 3.76 | 1.71 |
| B. successfully helped me plan my program. | 4.00 | 1.71 |
| Job success information on former graduates: | | |
| A. successfully helped me make career decisions. | 3.31 | 1.63 |
| B. clearly conveyed job opportunities available via this occupation. | 3.58 | 1.60 |
| Placement services at college: | | |
| A. successfully helped me find employment opportunities. | 3.26 | 1.87 |
| B. prepared me well to apply for a job. | 3.62 | 1.68 |
| Occupational instructors: | | |
| A. knew the subject matter and occupational requirements well. | 5.65 | 1.59 |
| B. were always available to provide help when I needed it. | 5.21 | 1.93 |
| Instructional support services (such as tutoring, lab assistance) : | | |
| A. always available to meet my needs and interests. | 4.26 | 1.24 |
| B. always provided by knowledgeable interested staff | 4.41 | 1.35 |
| Instructional lecture and laboratory facilities: | | |
| A. always provided adequate lighting, ventilation, heating, power and other utilities. | 5.55 | 0.74 |
| B. always included enough work stations for # of students enrolled. | 5.39 | 1.01 |
| Instructional equipment: | | |
| A. always current and representative of the industry. | 5.06 | 1.10 |
| B. always in sufficient quantity to avoid long delays in use. | 5.06 | 1.07 |
| Instructional materials (e.g., textbooks, reference books, supplies): | | |
| A. always available and conveniently located for use as needed. | 5.09 | 1.04 |
| B. always current and meaningful to the subject. | 4.97 | 1.29 |

"computers (plant specific)." Chemistry, item 16F, was the only topic in this area that stood out as substantially different between those employed in the energy field and those who were not, with a mean difference of 1.41 points.

Other questions on the survey asked about various components of the program, such as the instructors, facilities, and career services; these are summarized in Table 7. Some of the highest ranked items were instructors' knowledge of subject matter and instructional facilities; some of the lowest ranked items were job information and employment services.

## DISCUSSION

This study investigated the concerns, ideas, and recommendations for understanding current practices or sustaining those that best meet the needs of the stakeholders regarding development and implementation of the Energy Production Technology program. It was essential to assess the feedback process within this partnership to determine if the program was yielding effective results as perceived by program graduates and their employers. Equally important was to determine the role played by the advisory committee that was developed to implement and provide oversight to the program.

What the findings of this study brought to light was that, through the guidance of the advisory committee, the college developed a program supported by the NUCP and the outcome was qualified graduates. Also evident was that the feedback loop generally worked well, but there were times when it did not always happen and issues went unresolved. For example, feedback was seldom provided by the plants to determine how the program graduates were performing on the job. Based on this, a key update to the conceptual framework would be to develop checks and balances to the feedback process by incorporating more intentional opportunities for feedback, such as holding monthly outreach sessions with employers. It is unfortunate that, although the graduates were qualified, there were not enough positions available at the plants for all who were eligible.

To summarize research question one, the program was successful for creating a qualified workforce. The interviews for the study also served as a reflection and summary of the key events for the advisory committee during the program development. The following important points that surfaced during the actual study: making sure the college has the right stakeholders; making sure that the students are better prepared for the nuclear culture, which includes the entrance exams and an understanding of the market necessary for a right-sized student population. A key addition to the literature would be research how the findings in this study corroborate with key principles from experts (like the importance of nuclear culture, stakeholders and labor demand) in the OECD and MPR reports cited.

The second research question sought information from individuals who have employed graduates from the college's energy program regarding their perceptions about how the college program prepared students for employment in the energy field. Employers were also asked to complete a skills' checklist on the graduates they hired. The power plant employers believed that EPT graduates were adequately prepared for employment, although they felt that the military recruits were better prepared based on the culture in which they work. This was viewed as a shortcoming for graduates at the onset of their employment, but employers stated that EPT graduates did catch up with their military colleagues as they spent more time in the nuclear culture. The contrast between the two groups was not anticipated by the advisory committee but was obvious to the employers when asked.

To summarize research question three, from the viewpoint of the program's graduates, the students felt they were adequately prepared for employment. However it should be noted that the study uncovered opinions that varied on several topics based on whether or not the students were employed in the energy industry. For example, almost 90% of those employed in the energy field believed they were well prepared compared to 56% of those not employed in the industry. The largest amount of feedback in the additional comments was undoubtedly the frustration some students felt regarding the lack of employment opportunities. Several students made comments regarding the inability to get a job at the local plants because they neither had a family member who worked at the plant who could possibly help them get a job or they did not have previous time in the Navy. In terms of adding to the research, surveying the graduates fills a present gap in the body of literature, because this is the first known NUCP program evaluation that collected data from all major stakeholder groups.

Several recommendations for further research have surfaced as a result of this study. First, it could be valuable to replicate the program evaluation to include participants at multiple power plants across the country, which would allow for comparison data to be used by the nuclear oversight committees enabling them to gage the perceptions of programming currently provided by community colleges. The second recommendation is to replicate the study to include all students that have taken courses in the energy program that have attained a position in the energy field; because only program graduates were surveyed in this study, some data opportunities were missed that would have increased the sample size substantially. The final recommendation is to evaluate the success of mock entrance exams. There is not presently any research that evaluates how studying with a practice test helps students be successful on passing the entrance examination tests at the power plants. It may be effective to include this process in the curriculum and implement it at other community colleges, and such a test would likely increase the students' pass rate.

This study affects policy and practice in career and technical education (CTE) by continuing to support the current practice of linking CTE education to a third-party certified curriculum. In order to receive Perkins grant funds, the Carl D. Perkins Career and Technical Education Act of 2006 requires that CTE programs are aligned, if possible, with third-party assessments, in this case the NUCP standards. The study also demonstrated that expectations from an advisory committee are important to an occupational program, and also speaks to how prospective programs should have both a thorough needs analysis and periodic program evaluations, including a survey of graduates. A final lesson learned is that developing a new technical program involves much more than simply having the right technology.

## CONCLUSION

This study was initiated to find out how the EPT program at one Midwest community college successfully prepared graduates for a career in the energy industry.

*From the viewpoint of the business and industry advisory committee created to oversee the Energy Production Technology degree program:*

- The program was successful for creating a qualified workforce
- It is necessary to understand the job market and the culture, and it is important to retain the key players involved for decision making.

*From the viewpoint of the power plant employer:*

- Program graduates were adequately prepared for employment.
- There was a need to continually provide field experience and job shadowing opportunities to help students strengthen their awareness in the nuclear field.
- There was a need to create a stronger feedback loop within the program oversight process to help both the college and plant to continue a robust relationship.

*From the viewpoint of the program's graduates:*

- Students felt they were adequately prepared for employment.
- It is important to balance the job supply with the demand.

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# Applying the Congruence Principle of Bloom's Taxonomy to Develop an Integrated STEM Experience through Engineering Design

By Paul A. Asunda and Sharita Ware

## ABSTRACT

The concepts of interdisciplinary integration are interconnected beyond a theme, such that they cut across subject areas and focus on interdisciplinary content and skills, rather than subject-based content and skill (Drake, 1991; 1998; Jacobs, 1989). However, in today's learning environments, learning outcomes that teachers anticipate from their students and instruction are tied to educational standards. According to the principle of congruence in instructional design, in any situation, learning goals, anticipated outcomes, instructional strategies, and assessment methods should be carefully matched when designing a learning episode. To this end, this article presents a thought process by which the engineering and technology, science, and math teachers may reflect upon when preparing an integrated STEM course utilizing an engineering design process and the congruence principle of Bloom's taxonomy.

*Key Words: STEM, STEM integration, congruence principle, Bloom's taxonomy, engineering design, assessment*

## INTRODUCTION

Our ever-changing, increasingly global society has brought forth challenges that are interdisciplinary, and many require the integration of multiple disciplines, specifically STEM concepts to solve them (National Academies, 2006). Integrated STEM has been seen as a vehicle to meet this objective. Ideas behind integration of interdisciplinary courses are intersected beyond a given goal, emphasizing connections between subject areas and focusing on interdisciplinary content and skills, rather than subject-based content and skills (Drake, 1991; 1998; Jacobs, 1989). It has been perceived that STEM disciplines offer a rich amalgamation of experiences that provide contextual cross-cutting concepts embedded in technological problem- based activities that can be realized through engineering design. The teaching of STEM integration should not only focus on content knowledge but also should include problem-solving skills and inquiry-based instruction (Wang, Moore, Roehrig, & Park, 2011). However, Honey, Pearson, and Schweingruber (2014) posited that designers of integrated STEM education initiatives must be explicit about the goals they aim to achieve and design the integrated STEM experience purposefully to achieve these goals. They also need to better articulate their intentions about why and how a particular integrated STEM experience will lead to particular outcomes and how those outcomes should be measured.

In the field now called engineering and technology, the educational message has been "technological literacy for all," clearly advocating a general educational philosophy. Hill (2006) posited that in the absence of an extant high school subject area to develop proficiency in engineering design, technology education courses naturally offered a continuum of experiences that emphasized engineering design principles. These experiences require that students identify probable solutions to problems designed in a context, as they experiment with simulated resources that mirror everyday technological systems. Such systems may include mechanical, structural, fluid, electrical, electronics, optical, thermal, biological, and materials technologies. Through the combination of these technologies, students follow the same procedures used by engineering teams in solving real-world problems as they develop products, processes, or systems that support human enterprises and institutions (Smith & Gray, 2009).

Custer (2000) noted a unique opportunity for the field through curriculum integration; he posited that "if the technology education profession is successful with an integration agenda, we could well find ourselves at the core of education in the 21st century. But integrated learning environments will be very different, the risks and demands will be considerable" (p. 130). It follows that the infusion of engineering design into technology education through problem-solving activities that culminate into projects, offers students opportunities to develop critical thinking skills, technical, and STEM literacy knowledge, and helps them to learn innovative practices. For these reasons, integrative STEM education, which promotes learning through connections among science, mathematics, technology education, and other general education subjects, is wholly consistent with the ideology of the profession. *This article presents a thought process by which the congruence principle of Bloom's taxonomy may guide the engineering and technology, science and math teachers as they design and develop an integrated STEM course utilizing an engineering design process as the basis.*

***The Standards, Backward Design, and Developing Congruent Integrated STEM***

In today's learning environments, outcomes that teachers anticipate from their students and instruction are tied to educational standards. Proponents of standard-based educational reforms claim that standards offer teachers a congruent process in designing their instructional practice. By specifying what knowledge or skills students must demonstrate, standards point toward the instructional practices that teachers could employ (Cohen, 1996; Darling-Hammond, 2004; Rowan, 1996).

According to the principle of congruence in instructional design, in any situation, learning goals and outcomes, instructional strategies, and assessment methods should be carefully aligned (Chyung & Stepich, 2003; Gagne, Wager, Golas & Keller, 2005; Dick, Carey, & Carey, 2008). To achieve congruence, instructional design models suggest identifying intended learning outcomes that mirror objectives of a course and determining the types of learning activities that represent these objectives. Wiggins and McTighe (2005) capture the principle of congruence through the backward design process, a three-stage process that teachers can use to develop integrated STEM courses. More specifically, to start this process, teachers begin by asking themselves: What is worthy and requiring of understanding? To answer this question, one must consider local, state, and national standards. If the answer from this first question is not based on the standards, it is probably not worthy of teaching and learning (Reeve, 2002; Wiggins & McTighe, 2005).

Standards are the driving force behind today's education and they should be addressed in lesson design. Teachers of engineering and technology education have subscribed to Standards for Technological Literacy (STL) as a vehicle to integrate engineering design principles and concepts into the curriculum. The ITEEA board of directors (2009) stated that the content contained within the STL standards was the basis for students to develop 21st Century STEM- related knowledge —the very core of abilities needed for students to become advanced problem solvers, innovators, technologists, engineers, and knowledgeable citizens. Additionally, recent standards being integrated into the curriculum like the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS) seek to focus teachers on helping students make connections across the disciplines (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; NGSS, 2013). The underlying principles that inform both sets of standards are active engagement of students in authentic tasks, support for development of conceptual knowledge and reasoning, and application of knowledge in real-world contexts (Honey et al., 2014). Hence, standards present the content (knowledge and abilities) that teachers should utilize to develop contextual authentic tasks that support the development of conceptual knowledge and critical thinking leading to STEM literacy. It can then be argued that, for teachers to develop congruent integrated STEM courses, the backward design process helps students understand connections made between subject areas and internalize cross-cutting concepts rather than memorize them. In this way, learning outcomes and objectives serve as a cornerstone for the development of an integrated STEM course, helping to determine the instructional strategies and assessment methods that will be used which, in turn, helps to ensure the congruence of the instruction (Chyung & Stepich, 2003).

***Instructional Practices that May Reflect Integrated STEM in the Curriculum***

Furner and Kumar (2007) noted that, "an integrated curriculum provides opportunities for more relevant, less fragmented, and more stimulating experiences for learners" (p. 186). Integrated STEM has been viewed as an approach to teaching and learning in a manner such that the curriculum and content of the four individual STEM disciplines seamlessly merge into real-world experiences contextually consistent with authentic problems and applications in STEM careers. Such integration may refer to making meaningful connections between core disciplinary practices of each STEM domain being integrated, with the goal of using this integrated knowledge to solve real-world problems (Mobley, 2015). The integration of STEM concepts can then be visualized as follows, consider (see Figure 1) the content of units in Sciences, Mathematics and Engineering/technology education. Due to the overlap of concepts identified in these units, they may be considered for integration through a problem-based learning activity that culminates into a project enabling students to operationalize STEM concepts. In addition, the content and assessment type identified in the area that these disciplines intersect need to be clearly specified to assess learning outcomes. A second approach (see Figure 2) can be viewed as follows; units from the Sciences and Engineering/technology Education have been integrated. A unit from Mathematics is integrated with a unit from Engineering/ technology Education. Dugger (2010) noted that there are a number of ways that STEM can be taught in schools today. One way is to integrate one of the STEM disciplines into the other three (e.g., integrating engineering aspects into science, technology and mathematics). And a more comprehensive way is to infuse all four disciplines into each other and teach them as an integrated subject matter. In this regard, Erekson and Shumway (2006) noted that a full interdisciplinary model, in which the content from two or more disciplines are merged, has the potential to be very effective in technology education. Although this model appears to show promise, it also appears the most elusive. Thus, achieving congruence in designing learning experiences that simulate an integrated STEM course has revealed the challenges of making connections across the STEM subjects. Honey et al. (2014) suggested that instructors should build in their teaching *opportunities that make STEM connections explicit to students and educators (e.g., through appropriate scaffolding and sufficient opportunities to engage in activities that address connected ideas).*

## BASIS FOR CONGRUENCE PRINCIPLE

### *Bloom's Taxonomy and the New Revised Bloom's Taxonomy*

Bloom's Taxonomy is a hierarchical way of classifying thinking according to six cognitive levels of complexity. The lowest three levels include the following: **knowledge**, **comprehension**, and **application**. The highest three levels include: **analysis**, **synthesis**, and **evaluation** (Bloom & Krathwohl, 1956). Throughout the years teachers have encouraged their students to think through these cognitive levels and to operate at the higher levels when solving problems. For example, it has been perceived that a student functioning at the "application" level also has mastered the material at the "knowledge" and "comprehension" levels. To this end, the taxonomy is used as a framework for categorizing and classifying learning objectives according to the skill level required to meet desired learning outcomes. Outcomes describe what students are expected to know and be able to do by the end of a given instructional period. These outcomes relate to skills, knowledge, and behaviors that students attain as they progress through a given learning experience. Anderson and Krathwohl (2001) modified Bloom's taxonomy by adding another dimension of knowledge types: factual, conceptual, procedural,
and meta-cognitive. Factual knowledge can best be defined as the basic elements that all students must acquire within a discipline, whereas

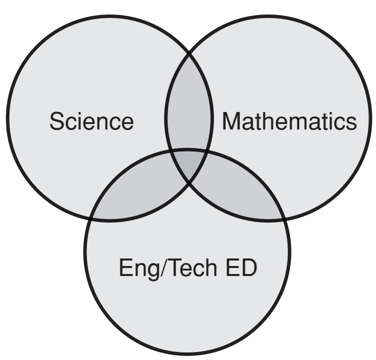


**Figure 1.** Integration of content units in Sciences, Mathematics, and engineering/technology education.

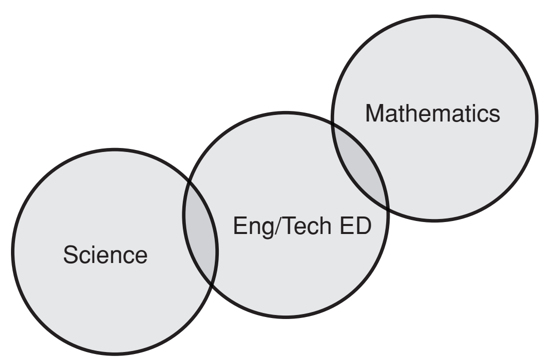


**Figure 2.** Integration of content units in Sciences, Mathematics, through engineering/technology education.

conceptual knowledge can best be defined as the understanding of inter-relationships among the basics of a discipline to the larger overall structure and explain how they function together. Procedural knowledge requires that students know how to conduct inquiry, understand and apply techniques and methods using appropriate procedures, and metacognitive dimensions require that students are aware of their own knowledge level, including the knowledge and use of heuristics. Anderson and Krathwohl renamed the earlier hierarchy of levels from nouns to verbs. A brief summary of the adaption and extension of Anderson and Krathwohl's (2001) revised Bloom's taxonomy follows:

1. Remember: recognizing, recalling (repeating verbatim): state [for example, the steps in the procedure for changing a flat tire].
2. Understand: interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining (demonstrating understanding of terms and concepts): explain [in your own words the concept of design].
3. Apply: executing, implementing (applying learned information to solve a problem): calculate [how much materials one may require to complete a given construction project].
4. Analyze: differentiating, organizing, attributing, checking, critiquing using existing criteria (breaking things down into their elements, formulating theoretical explanations or mathematical or logical models for observed phenomena): explain [why mass might affect the velocity of a given object].
5. Evaluate: (a) "Critiquing" based on self-designed/chosen criteria, (b) "Deciding" in the light of larger context, human values and ethics, (making and justifying value judgments or selections from among alternatives): select [from among available options for expanding production capacity, and justify your choice].
6. Create: generate, plan, and produce (creating something, combining elements in novel ways): make up [a homework problem involving material covered in class this week].

Bloom & Krathwohl, (1956) indicated that ideally researchers in each major field would use this taxonomy to develop their own unique objectives and language. They suggested that a discipline-specific taxonomy could offer assessment with greater details, with influences from experts in their respective fields, and break down the categories into subcategories and levels of education with new groupings and combinations.

The Accreditation Board for Engineering and Technology (ABET) evaluates every engineering-related program (departments and interdisciplinary course programs) in the United States and determines whether they meet certain standards (ABET, 2013). According to Felder and Brent (2004), this body determines whether the said programs and courses meet ABET- defined criteria and benchmarks that lead to realization of identified standards. Prior to a review of a program, instructors seek to evaluate the appropriateness of the educational objectives, the extent to which the specified outcomes result in the objectives, and whether they incorporate specific attributes specified by ABET. For engineering and technology education programs these would be ABET (Outcomes 3a–3k).

As STEM initiatives become the driving force of educational change through K-16, Clark and Ernest (2010) argued that all instructors would say that they want their students to master higher level thinking skills as reflected by the revised Bloom's taxonomy. To this end, the design of integrated STEM activities should focus on the extent to which the course's learning objectives map onto the outcomes, the feasibility of the specified outcome assessment and continuous improvement processes, and the seriousness with which the program is implementing those processes. Chyung and Stepich (2003) suggested that Bloom's taxonomy of educational objectives was instrumental in making sure there was congruence among the planning, instruction, and assessment process of design learning experiences.

## ROLE OF ENGINEERING DESIGN IN ENGINEERING AND TECHNOLOGY EDUCATION

Researchers, (Ereckson & Custer, 2008; Pinelli & Haynie, 2010; Wicklein, 2004) advocated for engineering as the focus for technology education because engineering provides a solid framework to design and organize curriculum, while providing an ideal platform for integrating mathematics, science, and technology. According to Atman et al. (1999) design is a central element of engineering, and all engineers perform some type of design function. Likewise, Warner and Morford, (2004) stated that design is fundamental to the study of technology, and design cannot be fully appreciated without an understanding of technology. This statement implies that, if technology is to be fully understood, then the concepts of design must be comprehended. The Standards for Technological Literacy (ITEA, 2000/2002/2007) Standards 8, 9, 10, and 11 highlight design concepts to be introduced throughout the K-12 curriculum. Hailey et al. (2005) posited that the design process described in Standard 8 for students in Grades 9-12 is very similar to the introductory engineering design process described in freshman engineering design textbooks, specifically the book by Eide, Jenison, Mashaw, and Northrup (2002). Hailey et al. (2005) noted two exceptions as highlighted in Figure 3, and Mosborg, Adams, Kim, Atman, Turns, and Cardella (2005) affirmed that the number of stages in these diagrams ranged from a few to several dozen, depending on the detail and complexity with which the design process is rendered.

Today, the field is witnessing exponential growth of engineering practices, STEM- related curriculums (e.g., Project Lead the Way, STEM Academy, CISCO investment in STEM, and Microsoft Math Partnership) are being introduced at the K-12 curriculum level. Additionally, the federal government in financial years 2009, 2010, and 2011 offered approximately $867 million to support activities related to STEM education and increased outreach activities that support STEM initiatives through organizations like the National Aeronautics and Space Administration (NASA), The National Science Foundation programs (President's Council of Advisors on Science and Technology, 2010).

These new initiatives and curricula imply that educators should design collaboration strategies and new instructional practices. As suggested by Chyung and Stepich (2003) Bloom's taxonomy

**Classical Engineeringy Design process**
(from introductory engineering text by Eide, et al.)

- IDENTIFY THE NEED
- DEFINE THE PROBLEM
- SEARCH FOR INFORMATION
- IDENTIFY CONSTRAINTS
- SPECIFY EVALUATION CRITERIA
- GENERATE ALTERNATIVE SOLUTIONS

Engineering Analysis
Optimization Decision

Design specifications
(So it can be made)

Communications

**Classical Engineeringy Design process**
(from introductory engineering text by Eide, et al.)

- DEFINING A PROBLEM
- BRAINSTORMING
- RESEARCHING AND GENERATING IDEAS
- IDENTIFYING CRITERIA AND SPECIFYING CONSTRAINTS
- EXPLORING POSSIBILITIES

Selecting an approach
and developing a design making
a model of prototype. Testing and
evaluating the design specifications
Refining the design

Communicating process and results

Creating or making it

**Figure 3.** Engineering design process compared to technology education design process

still has merit as a guide for instructional planning for two specific reasons. First, it reminds educators that the key to effective instruction is the congruence or "degree of correspondence among the objectives, instruction, and assessment" (Anderson & Krathwohl, 2001, p. 10). Second, because it is analytical, it helps remind instructors that learning is made up of a complex array of cognitive skills. At the same time, it doesn't prevent them from designing instruction in a more dynamic way, in which a low-level cognitive skill can be learned in conjunction with a high-level cognitive skill. To this end, the integration of engineering design into technology education continues to provide the field with authentic learning experiences that are ideal education required to help nations to prosper in the technologically interdependent world in which we live. Responsibility for this falls on the engineering and technology education teacher working in collaboration with colleagues in science and math.

## USING BLOOM'S TAXONOMY TO DEVELOP A CONGRUENT INTEGRATED STEM LESSON THROUGH ENGINEERING DESIGN

Haag, Froyd, Coleman, and Caso (2005) stated that data can only be collected on observable behaviors and ABET student outcomes do not define observable behaviors; therefore, learning objectives should be formulated for each outcome describing the desired observable student performance. This may imply that an engineering technology education teacher seeking to integrate STEM concepts into their curriculum may redesign traditional technology education problem-based activities into a STEM-integrated project that depicts a stated standard performance and desired outcome. Such projects may include (e.g., Cookie Package Design Challenge; Sustainable House Project, and more) that can be repurposed to deliberately help students realize how the STEM concepts being taught overlap in a given learning activity and how these lead to both the solving of a given design problem and the realization of a complete project product.

For the purposes of this article the authors utilized an air blaster car. The main focus of the design of this car revolves around four main areas: principles of aerodynamics involved with air blaster car construction, design of vehicle, construction of vehicle, and racing of vehicle. Such a lesson can be best illustrated as described by Figure 2 where scientific concepts that explain the principles of aerodynamics, and the mathematic principles behind racing the car (i.e., calculating speed based on the time the car will cover a given length, integrated with engineering technology principles behind design and construction of the vehicle). Given this activity, Wiggins and McTighe (2005) advocated for the backward design process, which prompts instructors to ask, how best do we go about designing the car, and what kind of lessons and practices are needed to master key performances? This approach also requires that educators operationalize the identified standards in terms of assessment evidence as they begin to plan a unit. Instructors are tasked with asking themselves, what they would accept as evidence that the students have attained the desired understandings and proficiencies.

The next steps will be to develop objectives, learning activities and materials, and evaluation of criteria for each of the four areas. At this point the congruence principle becomes particularly important. Maintaining the congruence among the objectives, learning activities, and evaluation criteria is critical to the effectiveness of the instruction. Congruent instruction means that learning activities are designed to support the objectives and that the evaluation methods are designed to assess important learning outcomes represented by the objectives. A curriculum mapping exercise would provide a snapshot of where educators stand in light of the anticipated learning outcomes that students will be able to demonstrate. Bloom's taxonomy of educational objectives is instrumental in making sure that there is congruence among the components of each module.

Bloom's original taxonomy was used to determine the levels of the objectives for each module and to design learning activities through which students would accomplish those objectives. Prior to developing learning activities, the authors determined the levels in the taxonomy for each objective. Because the learning sequence and processes are interdependent, it was listed as the highest level from the taxonomy, in conjunction with lower, supporting levels. These are summarized in Table 1.

**Table 1:** *Standards, Levels of Objectives, and Knowledge Dimension*

| STL/NGSS Standards | Objectives | Levels in RBT | Knowledge dimension in RBT |
|---|---|---|---|
| STL8-10-MS NGSS-MS-PS3-1. | Research pertinent information on underlying principles of aerodynamics with air blaster car construction | Remember and Understand | Factual |
| STL9, 16-MS, MS-PS3-3., MS-PS3-4. | Recognize principles of Newton's Third Law of Motion and how it relates to air blaster car competition | Understand and Apply | Conceptual |
| STL9, 16-MS MS-PS3-2. | Explain how mass, friction, and design of air blast car relate to its movement | Understand and Apply | Procedural |
| STL9-11-MS MS-PS3-4., MS-PS3-5. | Utilize the process of engineering design to design and develop a drawing design which shows understanding of air blaster concepts and construct a prototype car, present the model to peers | Apply, Analyze, Create and Evaluate | Meta-cognitive |

## DEVELOPING LEARNING ACTIVITIES FOR THE REMEMBER AND UNDERSTAND LEVEL (FACTUAL) DIMENSION

Research: Students were asked to conduct research into underlying principles of winning car designs. This could entail students' finding information about the basics of aerodynamics as it relates to cars and, specifically, the underlying principles into construction of these cars. Students may be asked to informally demonstrate their knowledge and comprehension of factual knowledge into the design of at least three different designs based on the aerodynamic design of the cars.

Students were expected to recall the underlying principles of aerodynamics in car design using terms that they elicited from the research activity and elaborate on them using more common terms to illustrate aerodynamic designs (e.g., shape, sleek outline, sometimes relating to with examples to show comprehension of the concepts). The teacher should give students opportunities where they can connect the factual to conceptual knowledge as they progress through the activity. This connection should help students construct and deconstruct knowledge as they understand and apply principles of Newton's Third Law of Motion and how it relates to air blaster cars through small group discussions. Through this process students may demonstrate the intended level of learning (comprehension) and then go beyond that to demonstrate an unanticipated higher level of learning (e.g., application, analysis, synthesis, or evaluation) by connecting factual to conceptual knowledge.

## LEARNING ACTIVITIES FOR THE APPLICATION AND ANALYSIS LEVELS (PROCEDURAL) DIMENSION

Based on discussions that ensue, the teacher should design classroom experiences that give students an opportunity to explore and explain how force, mass, friction, and design parameters relate to an air blaster car. By explaining and demonstrating the application of force on an object causes an acceleration of that object, that is, the more force you have, the faster an object goes, and helping students comprehend that force is not the only factor in the movement, or acceleration of an object. Other factors such as the friction, air or fluid resistance, and pressure may affect the acceleration as well. The students may be asked the following questions: Why is it important to be aware of how force and mass affect acceleration? What other factors may play a role? Why? How? Students eventually will be expected to apply these principles to the design of a car, Figure 4. Students can provide feedback to sketches of prototype cars for each other, and the can also provide examples of where they have seen these principles used. This method helped students consider different views of the same situation, promoting application and analysis.

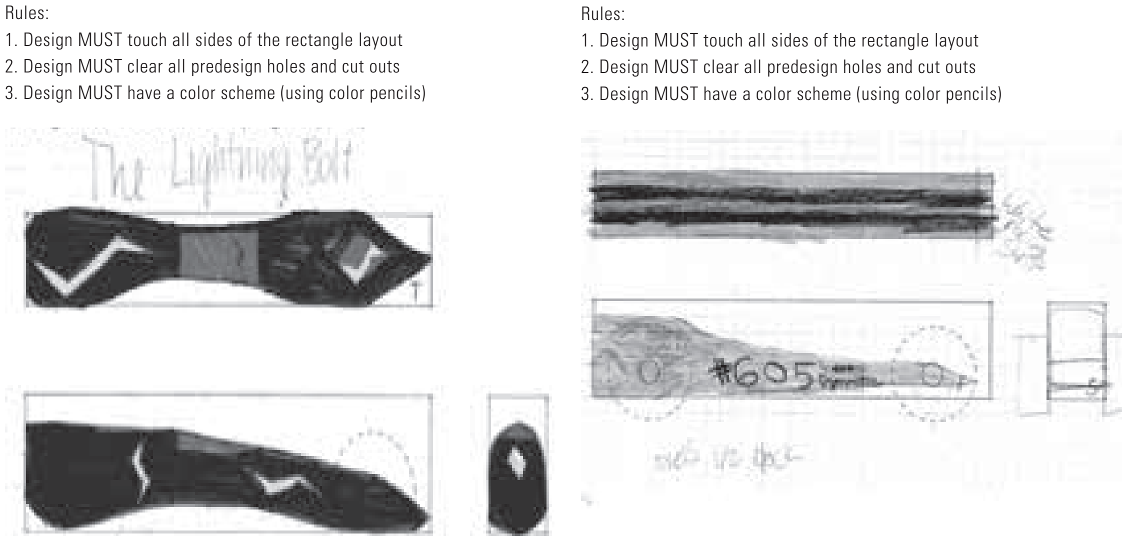


**Figure 4.** Students' sketches depicting factual and conceptual levels of Bloom's taxonomy

**Figure 5.** Students' prototypes depicting conceptual and procedural levels of Bloom's taxonomy

**Figure 6.** Students' prototypes depicting procedural and meta-cognitive levels of Bloom's taxonomy

**Table 2:** *Suggested Evaluation Procedure for Air Blaster Car Project to Integrate STEM concepts*

| STL/NGSS Standards | RBT Dimension | Activity corresponding to Original bloom cognitive processes | Suggested Evaluation |
|---|---|---|---|
| STL8-10-MS NGSS-MS-PS3-1. | Factual | Students to submit portfolio of sketches that document initial research of challenge, criteria and constraints they experienced used to design air blaster car, Car Design Sketches. | Complete submitted portfolios with at least 2 sketches, detailing the challenge, criteria, and constraints in the context of performance improvement. |
| STL9, 16-MS, MS-PS3-3., MS-PS3-4. | Conceptual | Speed and weight of car: students to record weight of their cars in grams, race car three times on a race track and calculate the speeds of their cars by utilizing the formula Speed = Distance / Time. Compare the data from their findings to those of their peers, and be able to explain how the weight (mass) of their car impacted the rate of the speed it travelled. | Application of the Formula speed = distance/time upon students recording of weight of the car and tie to race on a specified length track. Students provide an explanation of how the mass of their car impacted the speed compared to at least 2 peers. |
| STL9-11-MS MS-PS3-2. | Procedural | Manufacture (cut, shape, sand, paint, and detail) car as per chosen design utilizing provided materials and tools. Weigh car and race car on track 3 times and record the speed | Application of the process of engineering design and STEM concepts to design and manufacture air blaster car. |
| STL9-11-MS MS-PS3-4., MS-PS3-5. | Meta-Cognitive | Project reflection, students to write about their overall experience with project. For example, how their compared to peers, and what would they change about their car to make it better, faster. More aerodynamic? Smaller wheels? Shorter race track? | Justification of their selection of given design, and how these design modeled the design process and STEM concepts compared to the design of 2 peers. A description of how they can improve their design or their peers utilizing the engineering design process. |

They are required to keep a portfolio of sketches and drawings showing the development of the air blaster's final form. The design of this vehicle is not a linear process, and it is expected that many revisions of the design will occur. Thus, each student's car will have a different form that is based upon their design envelope (see Figure 5). Airblaster cars must be built to certain specifications to avoid interference with the propulsion system (i.e., placement of hole, wheels, launch system, guidance system, and the prevention of failure or destruction during testing). During the construction process, the students will learn to use tools, machines, and safety equipment, and they will identify potential safety hazards associated with them. Finally, the testing of the car will lead to both a self- evaluation as well as a peer evaluation process, as the vehicles are propelled down a track by compressed air (see Figure 6). The process of testing the cars will allow the students to compare and analyze the different designs for success and needed improvements. It is intended that a dialog between students will help further the design of the dragsters and improve results on the drag strip.

***Evaluating Engineering Design Process Learning Outcomes Based on Bloom's Taxonomy***

A backward design process as described by Wiggins and McTighe (2005) facilitates the design of an evaluation process. Each of the identified learning dimensions (i.e., outcomes, Bloom's taxonomy) guided the instructors in setting evaluation criteria that would be congruent with the learning objectives and standards. This evaluation maps the final products of a given task, to the learning objectives. Evaluating the design process regarding the degree to which the students have achieved identified learning outcomes with respect to integrating STEM concepts requires relevant, appropriate, and informative data upon which judgments can be based (Haag et al., 2005). A documented evaluation procedure (see Table 2) provides an approach to obtaining data relative to the process of engineering design in a technology education class project that may seek to integrate STEM concepts. Students could be provided the following guidelines for evaluations purposes.

## CONCLUSION

The rich products of technology education provide a context for successful integration of STEM concepts into the K-12 curricula. However, designing instruction that offers meaningful experiences to meet the challenges of STEM integration in technology education is a difficult task for any educator. A conceptual framework offers educators a reference point to their instructional practices and standards and provides educators with a blueprint of expected learning outcomes. STL standards offer a starting point for designing learning activities while NGSS seek to help teachers identify cross-cutting concepts across STEM disciplines in the context of their teaching. Wiggins and McTighe (2005) have suggested backward design as a strategy to help students understand the connections between subject areas and internalize cross-cutting concepts. Chyung and Stepich (2003) emphasized that instructional components, such as instructional objectives, instructional activities, and assessment methods should be carefully matched to help students achieve the intended learning outcomes. In closing, this article presents a locus by which technology education instructors can incorporate STEM concepts into the K-12 curriculum.
As instructors incorporate a backward design process to teach STEM concepts in technology education courses, Bloom's taxonomy can be a helpful guide in achieving congruence in integrating both cross-cutting concepts and how a particular integrated STEM experience may capture and enhance concepts that can be applied to solve complex challenges; it also may lead to both a particular outcome and the way in wish this outcome may be evaluated.

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# The 2014 Paul T. Hiser Exemplary Publication Award Recipients

## Jeffrey M. Ulmer, Douglas Koch, and Troy Ollison

"Characteristics of Today's Applied Engineering College-Level Educator"

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 XL, 2014.

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 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 (beginning with 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 distinct 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 than 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.