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Table of Contents

Current Recruitment Strategies for Pre-service Technology and Engineering Educators in Indiana
Megan McManus

Digital Communication Strategies for Elementary Students
Aaron R. Gierhart

The Needed Math Conference: Closing the Gap between the Math that's Taught, Learned, and Needed
Michael Hacker

Visuacy: Value in STEM Creative Work
Tan Seng (Jason) Chong and Chia Soo Chin

Towards a Design Thinking Culture
Chia Soo Chin and Tan Seng (Jason) Chong

Teacher Shortage and Alternative Licensure Solutions for STEM Educators
Britton H. Devier and Kurt Y. Michael

Kids Teaching Kids: A Guide for Working with a Chapter Team
Joe R. Busby, Brent Curran, and Shane Westhafer

Preparing Students for TSA Middle School and High School System Control Technology
Brent Curran, Joe R. Busby, & Shane Westhafer

Incorporating STEM in Middle School Intervention Courses
Jay Bradley

Increasing STEM Awareness in Underrepresented Populations – Actualizing STEM Potential in the Mississippi Delta
Daniel L. Trent

Validating Industry Recognized Credentials
Daniel L. Trent and Virginia Jones
Current Recruitment Strategies for Pre-service Technology and Engineering Educators in Indiana

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Abstract: Indiana has seen a large jump in the number of Technology/Engineering Education (TEE) job openings over the past five years but is struggling to find candidates interested in majoring in the area. There is a shortage of TEE teachers in middle and high schools as well as a shortage of candidates majoring in this degree. Both university faculty and current TEE students in Indiana had the opportunity to voice their opinions as to what they perceived and what they experienced when they were recruited into the major. Surveys were completed, and interviews were conducted with those who were willing to participate. Themes were analyzed and the following results were found: faculty and students both agreed that the most influential factor in choosing the TEE major was a current or former high school teacher.

Context

Career and Technical Education (CTE) is a significant component of the public high school system. Many students who take CTE courses are at-risk students who have low motivation or are at risk of dropping out (Auger, 2015). Teachers who teach the engineering and technology branch of CTE hold degrees in TEE (Bureau of Labor Statistics, 2018). Many high school students have realized that they will be better prepared with job-ready skills; therefore, CTE courses have seen large amounts of enrollment (Bradley, 2016). The problem has not become enrollment of students, but who is going to teach them.

The number of TEE pre-service teacher programs has dropped by 11% from the academic year 1990–2000 until the time of this study, and continue to be eliminated (Guarino, Santibañez, & Daley, 2006). The need for prepared and highly qualified teachers is critical, but pre-service teacher programs are also experiencing a shortage. In order to fill the growing need for career-ready individuals, the nation employed approximately 2.25 million new teachers between the years 1994 and 2004, and during that same time period of time, approximately 2.7 million teachers left the profession (Conneely & Uy, 2009).

Purpose

The purpose of this study was to inquire about the current pre-service TEE shortage and investigate how universities in Indiana have been recruiting those majors. This study intended to provide insight that should promote successful recruitment efforts in the field of pre-service Technology and Engineering Education within the state of Indiana. This study may be beneficial to faculty and universities in their attempts to grow TEE programs. By understanding the TEE shortage trend and how current programs are recruiting, future efforts can be focused on these aspects to increase enrollment of pre-service TEE teachers.

Methodology

The three four-year institutions in Indiana that offer the TEE major were invited to participate in the study. These universities were Ball State University, Indiana State University, and Purdue University. To begin the research, data was collected from the Indiana Commission for Higher Education to determine if there was in fact a shortage of TEE majors in the state. Once a shortage was determined qualitative and quantitative methods were used to survey participants. Both university faculty and current TEE students had the opportunity to voice
their opinions as to what they perceived and what they experienced when they were recruited into the major.

**Literature Review**

In the time period of 2008–2010, the United States documented TEE as a high-need area for teachers (U.S. Department of Education, 2015). Again in 2016, the need was still present and persisted into the 2017 school year. A shortage of TEE was also seen across the Midwest and the rest of the United States (U.S. Department of Education, 2016).

A study conducted by Love, Love, and Love (2016) showed that TEE degrees awarded have dropped significantly in Indiana alone from 6,368 degrees being awarded in 1970 to only 245 being awarded in 2015. Chapman (2017) summarized a survey conducted by Indiana State University in which the teacher shortage in Indiana showed 94% of districts have a shortage of teachers in all areas. Within this report, 30% of districts were lacking science and technology educators to teach Project Lead the Way (PLTW) classes, which are most commonly taught by TEE teachers (Loughlin, 2017).

TEE pre-service teacher preparation programs at the post-secondary level prepare highly qualified teachers to fill positions in the secondary school classrooms. Nationally there is a shortage of TEE educators coming from teacher preparation programs. TEE has been documented as a high need area for teachers (U.S. Department of Education, 2015). The state of Indiana follows this trend. Current recruitment efforts have been studied to find a solution to the TEE shortage, but remain “inadequate to meet the demand” (Scarcella, 2000, p. 1).

**Findings**

The results of this study indicate that there is a high demand for technology educators and a low supply at the university level. The enrollment trends and corresponding teacher position openings in TEE showed that there is a teacher shortage. The year 2017 saw 246 job openings in the state of Indiana but only 46 students enrolled within the TEE major who could ultimately become teachers.

The faculty stated that the support of current faculty, high school teachers, and counselors were the major factors that influenced students to choose the TEE major, although most often TEE was not the student’s first choice but instead tended to recruit their current students from another engineering or education major. Retention methods that faculty believe to be working in their programs are the individualized attention given by faculty to students within the major and the efforts of faculty to develop a sense of community and ensure a positive student teaching experience. Faculty have many ideas of how to improve recruitment and retention in their programs, but money seems to be the biggest factor preventing new methods from being tried.

The majority of students did not choose TEE as their first choice as a college major but instead chose some type of engineering and later switched to the TEE major. Their biggest influence in choosing TEE was a high school or middle school teacher. When asked what kept them in the TEE major, the strongest influence came from an interest and success in the coursework.

Faculty and students agreed that the most influential factor in recruiting students into the TEE major are current secondary teachers. Students who enroll in TEE took technology-based classes in high school, and the teachers they had combined with an interest in the coursework are what brought them to enroll in the TEE major. The faculty at each university are working hard to give individualized attention to each student once they are enrolled to ensure that they succeed in their course work. Students remain in the courses because they are successful. In order to continue to enroll TEE majors, universities must continue to work with current middle/high school teachers and support the college students enrolled in the major.
Recommendations

As the data suggested, current teachers are the most influential in recruiting students into the TEE major. Along with researching how to encourage current teachers, more research could be conducted into how universities are using principals and counselors to spread the word about careers in technology education. Another suggestion for future research would be to look into the licensing processes and benefits in other states. Along with that, research could be conducted to compare in-state and out-of-state tuition for those states with large TEE enrollment to see if that is a factor in the low enrollment within the state of Indiana.

Research could be conducted further into the teacher shortage as it pertains to TEE. This research would need to cover more areas than just a single state. A major factor that could be causing the teacher shortage is the stigma that is facing education (Cores, 2013). Research could explore that stigma and how to reverse it in order to have more students interested in pursuing an education degree.

References


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Digital Communication Strategies for Elementary Students

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Abstract: Communication approaches mediated by digital technologies can be utilized with and by elementary learners for authentic purposes to foster the development of technological literacy. In this session, the presenter shared digital communication strategies he has used with third grade students, highlighting the affordances of current technological tools and the pedagogy behind the design of these learning opportunities. Some of the activities that were shared include digital science notebooks, analyzing digital primary sources, data input and digital graphing, blogging, web design, and interest-based digital research.

Introduction

In this session, I shared several digital communication approaches that I have used with elementary learners. Communication approaches mediated by digital technologies (Jones & Hafner, 2012) can be utilized in elementary learning settings for authentic teaching and learning purposes to foster the development of technological literacy called for the Standards for Technological Literacy (ITEA/ITEEA, 2007). After describing the teaching context in which I implemented these digital communication approaches, I will discuss how elementary teachers might evaluate the use of digital technologies in their own instructional design. Finally, I will share and describe examples of some of the strategies I presented in this session at the ITEEA 2019 Conference.

Context

I previously implemented all of the digital communication strategies shared in this session with my third grade students in rural Illinois. Many of the approaches in which my students and I have used Google Classroom and the G Suite of apps originated from a pilot of these tools during the 2016-2017 school year using one-to-one iPad Mini devices (Gierhart & Brown, 2018). The results of the pilot contributed to the district’s replacement of the iPads with one-to-one Samsung ChromeBook laptop computers for third grade students.

Evaluating Digital Communication Approaches

It is critical that digital technologies are integrated in educational settings, at the elementary level or otherwise, with integrity. The viability of using technology in the classroom rests on the premise that these innovations transform the outcomes of teaching and learning (Cazden et al., 1996, Yelland, Cope, & Kalantzis, 2008). Elementary teachers should ask the following questions when choosing a digitally-mediated communication approach to use with students:

- Does the use of technology simply replace traditional teaching and learning approaches or transform them (Puentedura, 2014)?
- Does the technology make teaching and learning more socioculturally authentic (Leu, O’Byrne, Zawilinski, McVerry, & Everett-Cacopardo, 2009)?
- Does it facilitate deeper social engagement and ethical interaction with others (Gierhart, Bonner, Smith, & Seglem, in press)?
- Does it foster opportunities to effectively facilitate or contribute to student learning in our technologically-mediated world (ITEA/ITEEA, 2007)?

Examples of Digital Communication Strategies

Table 1 depicts an overview of each digital communication approach shared in this session along with current digital tools that elementary teachers could use to implement similar activities with students. Also featured are the ITEEA (2007) Standards for Technological
Digital Science “Notebook”
I form groups of three students for our science inquiry work and create a Google Site for each group, sharing the editing permissions with each group member while assigning myself as the “Admin.” Not only can I hyperlink and/or embed digital resources for labs and activities, but I can also log feedback to the students’ work directly on their webpages. This allows them to make simple edits and revisions based on my assessment input instead of having to erase or completely redo work that may be uneasily changed on physical paper.

As an example, in a unit of study about force and motion concepts, the students completed a design challenge in which they had to design a rolling cart apparatus with limited materials. The goal was to roll a prototype down a ramp using only the force of gravity. Later, they brainstormed and implemented improvements after learning about the concept of wheel bearings to increase the rolling distance.

For each lab, I pose a focus question that is featured on a corresponding page on each group’s Google Site. The students use FlipGrid, a website that facilitates private or public video response and dialogue between students and teachers, to respond to these questions. The video format allowed students to show their prototypes and demonstrate the improved functionality of their carts rather than just describing them in writing.

Multimodal “Text” Composition
Students must be able to produce, comprehend, and interact with media other than traditional, print-based texts (Lankshear & Knobel, 2003, 2007). Elementary teachers must leverage digital modes (e.g., audio, video, images, hypertext, etc.) in ways that support students in communicating for authentic purposes. Students can produce, post, embed, and share digital products of learning and engage in dialogue about them, in-person and/or asynchronous, making these living “texts.” Table 1 suggests a few current apps or sites that I have used with my third graders toward this end.

Interest-Based Research Projects
During the current school year, I have set aside time on Friday afternoons for students to pursue interest-based research projects independently or in small groups. As an iteration of the Genius Hour model (Seglem & Garcia, 2018), I guide students in posing a focus question around their interest and digitally researching and investigating it, creating print or digital
media products to share their learning. All of their products are published (as we scan or photograph physical media, such as posters) on Google Sites.

For example, some students prefer to share their learning conversationally by recording podcasts using an open-source audio recording site called Vocaroo. I work with them to export and share their episodes on a WordPress blog I created that serves as a hub for all of their podcast series. Others have created digital letters with questions to share with experts via my professional social media platforms (e.g., Twitter, Instagram) or email. One group that was researching arts and crafts were fortunate enough to receive a reply from a popular YouTuber named Moriah Elizabeth. This group created and embedded a Google Slides presentation on their Google Site sharing the answers they received from her.

Conclusion

While the digital tools discussed in this session will evolve, change, and be replaced with newer technological innovations, the pedagogical approaches associated with them can continue to be utilized. Pedagogy will always remain in dialogue with a myriad of factors teachers must consider (Britzman, 2003), technological literacy demands being among them. Technology, and the vision set forth by the STL (ITEA/ITEEA, 2007), are ineffective without sound teaching practices. Let the strategies shared in this session be but a starting point in shaping those that best meet the learning and technological literacy needs of students within your context of influence.

References


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The Needed Math Conference: Closing the Gap between the Math that's Taught, Learned, and Needed

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Abstract

The Needed Math Conference, supported by the Advanced Technological Education (ATE) program of the National Science Foundation, focused on bringing to light how mathematics education might better reflect the concepts and skills that are prerequisites for postsecondary technical programs and for successful employment as technicians in STEM-related fields.

Employers, instructors of technical subjects, and mathematics educators who participated in a three-day conference on January 12-15, 2018, concluded that students’ mathematical competence should be strengthened by enhancing their ability to solve problems found in real-world contexts.

Proceedings can be found at: www.needed.math.org

Motivating Rationale and Needed Math Conference Overview

Context

Many students are disenfranchised from mathematics because they do not see how the subject as they study it in school applies to their everyday lives and future careers. Although we might like all students to be drawn to study mathematics by its elegance, to appreciate its patterns, rigor, and structure, and to learn through its study to think abstractly and reason logically, a curriculum aimed at such lofty goals can result in convincing many students that they lack some innate ability and are thus doomed forever to be “bad at math.” The insecurity that this engenders then becomes a self-fulfilling prophecy that endures into adulthood, and mathematics instruction becomes a barrier not only to further education but to career goals as well.

The current K-12 math curriculum and pedagogy all too often produce students who are ill-prepared for employment in the technical workplace. Employers report that, despite studying mathematics in every grade from kindergarten through high school and beyond, the graduates they hire often don’t know how to tackle the kinds of problems that typically arise in the workplace. For example, while the “renaissance” in manufacturing is a positive development for the economy, employers surveyed for the Manufacturing Institute’s 2015 Skills Gap study reported an obstacle: a “sizeable gap” between the talent they need and what is available in the job market. The respondents – over 450 manufacturing executives listed math skills among the most serious deficiencies, along with technical and computer skills and problem-solving ability. An analysis of skills gaps in four industries including manufacturing found significant “foundational skills gaps” particularly in applied mathematics (Manufacturing Institute and Deloitte, 2015).

The Needed Math Conference, held on January 12 to 15, 2018, brought together employers in three STEM fields (biotechnology, manufacturing technology, and information and communication technology), postsecondary instructors of technical subjects related to those fields, and mathematics educators. There was consensus among them that there is a significant gap between the math that students are taught, tested on, and retain beyond school and the mathematical skills and abilities they need to solve problems commonly found in real-world contexts and that this likely contributes to the undersupply of skilled workers prepared...
for successful careers in STEM-related fields. Employers felt there will be a continuing need to revisit math curricula to ensure that they align with the needs of technicians in the 21st century workplace. Anecdotal evidence suggests that the inadequate mathematical preparation among high school graduates is reflected in a gap between the number of applicants for postsecondary training in STEM fields and the number of academic openings available.

The problem is complex, and the solutions to it are correspondingly varied, but the basic recommendation from the Conference is that the mathematics standards, assessments, and curriculum be revisited and revised so as to place greater emphasis on the skills needed to solve the kinds of problems that arise in the real world. Although the Conference participants represented only STEM fields, several of them noted that the kind of mathematical skills useful in those areas – e.g., mathematical modeling, statistical reasoning, and systems thinking – are valuable in many other career paths.

We recognize that implementing the recommended changes will be a complex and challenging undertaking, one that is likely to take years to accomplish and require engaging a great many diverse communities with varying interests and constituencies. Therefore, to support the effort, we recommend placing greater emphasis on contextualized math instruction. We urge an increased focus on topics that support teaching math in context and a corresponding shift in emphasis in the instruments that are used to assess learning. We argue that the current mathematics-for-all curriculum and assessment framework should be augmented by establishing a separate mathematically rigorous pathway based on realistic problems representative of those that many students will encounter after they leave school.

Continuing the dialogue among groups that appear disparate but are united in their greater goals is essential. In an ever-more connected world, there is little excuse for not creating a platform for such communication. This conference could be the seed that grows into a full, easy-to-use communication line among the various groups concerned with math curriculum, teaching/assessing, and utilization.

**Purposes of the Needed Math Conference**

The purposes of the Needed Math Conference were to (1) facilitate conversations among employers, instructors, and math educators and researchers leading to an identification of the math competencies skilled technicians need to be successful in the workplace and (2) motivate math educators and researchers to investigate how teaching needed math can broadly increase mathematical understanding. Specific Conference goals were to:

- Develop a consensus and shared understanding among the three Conference communities about the math that skilled technicians in the three Conference domains need to be successful in the workplace.
- Determine where in the curriculum this needed math is or should be taught and what evidence we have that these topics are learned, remembered, and can be applied beyond the mathematics classroom.
- Identify examples of tasks that are difficult for technicians to accomplish and which a better understanding of needed math concepts would resolve.
- Create an enduring community of stakeholders who care about how people learn, or do not learn, the math needed for workplace success.
- Publish articles in appropriate journals (including journals for math educators, other STEM educators, school board members, and school administrators) and disseminate Conference proceedings.
Approach and Methodology

Fifty people attended the conference. Three STEM domains were about equally represented: biotechnology, information and communication technology, and manufacturing technology. Each domain included employers, instructors, and mathematics educators. Participants met in three types of groupings, facilitated by steering committee members. Conference met as a whole group. All participants in the same domain met, facilitated by a domain-based Steering Committee member. Affinity groups of all employers, instructors, and mathematics educators met separately.

Data Collection

A researcher and an external evaluator worked together to frame survey questions and analyze participant responses. Templates were provided to the groups to structure data collection during these meetings.

Findings

Finding 1. There is a gap between the typical textbook problem and the problems that arise on the job even though the underlying mathematics may be the same.

Finding 2: There is a gap between the mathematical preparation many students receive and the math requirements of an increasingly technological workplace.

Finding 3. Too many students cannot make effective use of technology commonly found in the workplace.

Finding 4. As currently taught and assessed, math education has become a barrier to success for many students rather than the pathway to it.

Recommendations

Recommendation 1. Place greater emphasis on contextualized math instruction at all grade levels and in all mathematics courses.

Recommendation 2. Shift emphasis in the assessments that students must take.

Recommendation 3. In all math courses, increase the focus on topics, approaches, and pedagogy that better reflect the demands of the contemporary workplace.

Recommendation 4. The current mathematics-for-all curriculum and assessment framework should be augmented by establishing a separate mathematically rigorous pathway based on solving realistic problems representative of those that many students will encounter after they leave school.

Recommendation 5. Create a Needed Math Center charged with expanding the reach of the conference findings to additional stakeholders, holding follow-on conferences on relevant topics, publishing articles aimed at a wide variety of audiences including policy makers at the state and federal levels.

Acknowledgement of Support

The Needed Math Conference was funded by the National Science Foundation’s Advanced Technological Education program (Grant number: 1737946).

References

References accompanied the Needed Math NSF proposal. The proposal and reference list are available upon request.

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Visuacy: Value in STEM Creative Work

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Abstract:
Visuacy or visual literacy, in the light of the ability to sketch, is defined as the ability to appreciate, understand, initiate, articulate and manipulate visuals. It forms part of the human development that is essential for creative work: designing, engineering and even STEM education. This paper expounds on the value of visuacy in the context of sketching-to-design by secondary school students in the subject Design & Technology. It also seeks to understand the act of developing a creative-self via the process of sketching-to-design. The research is based on the author’s sketch work from 2009 to 2019. The endeavour seeks to understand the educational value of sketching to inform its teaching as a design thinking tool.

Introduction
Creativity – a specific interplay between imagination, improvisation, and innovation – is among the most valuable human qualities achieved during the process of learning and teaching (Karwowski, 2015). Teaching creativity is one aspiration of many education systems. This is often also part and parcel of STEM education for meaningful learning set in real-world contexts. But how should creativity be taught and nurtured?

There is creativity in the design fields, among many others. Probing conversations with design practitioners revealed that they sketch extensively to think in order to design, quite intuitively and tacitly. These sketches are not showed almost all the time, except the final rendered drawings. Designers’ sketching-to-design ability is often assumed and not discussed. Nonetheless, the author gleams from the practice a potential for purposeful-quantitative sketching as an important endeavour in designing for creative insights that leads to growing a creative-self.

Background
Design & Technology (D&T) is a subject taught in Singapore secondary schools to inculcate in students an added dimension of thinking and doing through designing and making three-dimensional purposeful objects. One outcome of which is sketching-to-design, a designerly disposition to be developed in students. This is based on an aspect of non-verbal mode of representation among others (Cross, 2007) that anchors the philosophy for D&T practice, which should be as essential as the 3Rs (reading, writing and arithmetic).

In creating the resources to train D&T teachers for this aspect of teaching, the author proposes that the creative-self in students can be nurtured. To this end, a visuacy-centric pedagogical model is being sought.

Theoretical Framework
Research studies (Schon, 1983; Banerji and Elmitt, 1994; Robbins, 1994; Goel, 1995) empirically concluded that sketching during the conceptual design (early) stage plays an important role in the labour of creative ideas and the process can be at times painful. This is so as newly formed and still vague ideas needed to be externalised in design sketches that are less rigid and ambiguous for visual/spatial reasoning. To develop design ideas from their infancy to sophistication requires cyclic behaviours of sketching. (Suwa, Gero and Purcell, 2006). Schon (1983) calls this behaviour “a reflective conversation with his or her ideas”.

12
The phenomenon behind the extent of a sketch is explained by Goldschmidt (1991) as conversational growth with one’s mind and the sketch – a sketch is created from current knowledge; reading/interpreting the resulting representation creates new knowledge. The creation of a sketch is described as seeing-that reasoning, and the creation of new knowledge as seeing-as reasoning. The two reasoning acts intertwine, and are essential and powerful visual thinking acts of sketching-to-design. It clarifies a person’s figuring/sorting out process using sketches.

Smithers (2001) expounds that “designing is taken to be a kind of thinking, as a kind of mental problem solving. In principle, all designing could thus take place inside the head of the designer, with no external signs of any designing happening until the final design is delivered. In practice, this is not what usually happens: designers make and use so called external representations, and in particular, they make and use sketches, especially in the so called early stages of any designing”.

**Approach to the study**

Randomly selected design outcomes from the teaching resources created by the author are used in this study. They are as follows:

- 24 design outcomes for pre-service training of D&T teachers, from 2009 to 2016.
- 23 design outcomes for in-service training of D&T teachers, from 2017 to 2019.

**Discussion**

Figure 1 shows an example of sketch-to-design process. Each design outcome is unique and it emerged from a series of sketches. The sketches that lead to the each design outcome are authentic in trying to figure out what-next and what-if. There is no predetermined number of sketches to be made to lead to a design outcome. Some processes are lengthy, and some are quick and short. Generally, there is a need to make a series of sketches to arrive at a potential design outcome. The series of sketches reflects the seeing-that and seeing-as reasoning model (Goldschmidt, 1991).

A pertinent application in D&T teaching and learning is purposeful-quantitative sketching-to-design. The enactment with templates as pedagogical scaffolds (Figure 2) allows students to design while sketching, developing confidence in the act of sketching as they attempt numerous episodes of designing. The development of sketching-to-design knowhow is key to cultivating a creative-self in the individuals and henceforth adds another dimension of thinking to the individuals.
Conclusion

This study affirms the following:

a) The ability to sketch is important in the act of designing, and in the pursuit of a creative-self.

b) Quantitative sketching, generally, is pertinent to the creative act and it is important to develop a visual-nonverbal language, in addition to the 3Rs, in our students.

c) D&T education is also embedded with STEM and visuacy – the ability to sketch to design – as an important value in STEM creative work. This needs to be considered as another important creative language to be developed in students to propel them further.

References


Towards a Design Thinking Culture

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Abstract:

Singapore Design & Technology (D&T) fraternity sets itself the vision “towards a design thinking culture” in 2002. This paper recounts the importance of the vision statement to direct classroom practice that is educationally developmental and 21st century competencies centric. The D&T teaching practice has grown in the last three decades: 1986 to 1995 – the start; 1996 to 2005 – the shift; and 2006 to present – the shaping. In deliberating the practice, the D&T teaching fraternity now shapes a practice that contributes to the development of students as persons, with reference to the D&T education teaching and learning framework.

Introduction

“Towards a design thinking culture,” a vision statement written in 2002, for a subject in the school curriculum was unprecedented. The young subject leadership then saw the need for one to steer a teaching fraternity of mostly trained engineers to engage 13- to 16-year-olds in learning experiences that are educationally developmental and yet future-relevant. Design thinking here refers to the thinking that one engages in when designing and it involves making.

The start (1986 to 1995)

D&T was first implemented at Secondary One in 1986 to replace Woodwork and Metalwork in response to Singapore’s changing economic landscape. It is compulsory for both boys and girls at the lower secondary level, and an elective at the upper secondary level. The subject engages students in designing and prototyping ideas through the minds and hands.

During those early years, teachers of the outgoing technical subjects were retrained to teach D&T, as engineers were recruited and trained as D&T teachers. Understandably, teaching was content-centric and approach to designing was formulaic. The evidence of learning (Figure 1) comprised design sheets of deliberate drawings of ideas with more words than sketches, and artefacts that were reminiscence of the defunct technical subjects.

![Figure 1: Outcomes that are representative of learning at the start of D&T education](image)

The shift (1996 to 2005)

Into the second decade of D&T practice, some students’ works (Figure 2) with a good flavour of designerly acts started to emerge. Design sheets were somewhat close to design working
sheets (Denton, 1993) and the artefacts were solution-focused – a shift from the craft-centric outcomes.

![Figure 2: Outcomes that are representative of learning desired of D&T education](image)

D&T educators who turned to industrial design practice and design education related academic research to inform classroom practice are to be credited. Their efforts contributed to the shared belief that D&T offers opportunities to shape students’ values and attitudes, and develop skills that are crucial to their development (Archer, 1974 & 1975; Cross, 1982 & 2007). It forms the foundational lead in the search for a philosophy of practice in D&T education (Chia and Tan, 2011) that will contribute to the holistic development and education of students. ‘Towards a design thinking culture’ as a vision for the fraternity was written in 2002 to guide the journey for a design-oriented practice in D&T education.

**The shaping (2006 to present)**

The shaping of the D&T teaching practice rightfully began in pre-1986 when teachers were retrained to teach via prescribed resources. With a different teacher profile today, it has evolved to in-service training for teachers to design and make at lower secondary level so as to create resources with pedagogical scaffolds to enable learning (Figure 3). This is to encourage a pervasive design-oriented classroom practice.

![Figure 3: Use of templates for sketching to design and design outcomes](image)

There are other platforms like seminars, dialogue sessions and learning communities for teachers to discuss classroom practices. The underlying reference is the D&T syllabus that has been revised a few rounds; each round driven by the need to close the gap between the intended and the enacted curriculum. To this end, a practice that focuses on cognitive development via visuacy and graphicacy, and three-dimensional object manipulation is very much valued. This is anchored on three main areas of justification for design education within general education, namely, *design develops innate abilities in solving real-world, ill-defined problems; design sustains cognitive development in the concrete/iconic modes of cognition; and design offers opportunities for development of a wide range of abilities in nonverbal thought and communication* (Cross, 2007, p. 30).

The growth in D&T practice has led to a framework (Figure 4) for the teaching fraternity. It gives meaning to the different parts of the subject matter for developing designerly dispositions in the students.
Conclusion

Towards a design thinking culture as a vision has guided Singapore D&T education thus far. The quest to grow a culture continues as the fraternity develops design thinking as a way of thinking and doing vis-à-vis sketching and making.

References:

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Teacher Shortage and Alternative Licensure Solutions for STEM Educators

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Abstract:
Career and technical education (CTE) continues to face an annual shortage of qualified teachers in the profession. This shortage has caused an increase in the use of alternative certification/licensure pathways across all 50 states and the District of Columbia. These alternative pathways are highly divergent from state to state. Limited research has investigated the alternative certification/licensure requirements that may contribute to CTE teacher shortage. This predictive correlational study looked to determine if CTE alternative certification/licensure requirements could predict CTE teacher shortages. Logistic regression was used to analyze the data. It was found that CTE alternative certification/licensure requirements were not a good predictor of CTE teacher shortage.

Background
In 2002, the No Child Left Behind (NCLB) legislation made an effort to improve student achievement through increased accountability (Fletcher Jr., Gordon, Asunda, & Zirkle, 2015). A highly qualified teacher, as defined by NCLB, is a teacher who has a bachelor’s degree or greater and a solid understanding of the subject matter as evidenced by passing a standardized test (Fletcher Jr. et al., 2015). These requirements become problematic for career and technical education (CTE) teachers, specifically for those who are alternatively certified because of the uniqueness of CTE.

Since 2015, media reports of teacher shortages have appeared in nearly every U.S. state (Behrstock-Sherratt, 2016). In Our Future, Our Teacher (2011), the U.S. Secretary of Education projected that 1.6 million teachers will retire over the next decade. In the U.S. Department of Education’s August 2016, Teacher Shortage Areas, 31 states and the District of Columbia report a shortage in at least one area of CTE, including technology and engineering education. As a result, an increased number of alternative certification programs have emerged. In 1982 just eight states offered alternative certification/licensure, that number now includes all 50 states and the District of Columbia (National Center for Educational Information, 2003, 2010).

Purpose
The purpose of this predictive correlational study was to examine the extent CTE certification/licensure requirements can predict CTE teacher shortages for the school year 2016 - 2017 throughout the United States. This study was significant to the topic of STEM and CTE teacher shortage in relation to alternative certification/licensure requirements. Most states credentials technology and engineering educators under CTE, however, there are few, studies that focus specifically on CTE alternative licensure (National Center for Career and Technical Education Research, 2007). For this reason, the following research question was investigated, and the null hypothesis was tested:

RQ1: Can CTE certification/licensure requirements predict CTE teacher shortages for the school year 2016 - 2017 throughout the United States?
**H₀₁:** There is no significant relationship between the criterion variable (CTE teacher shortage) and the combination of predictor variables for CTE certification/licensure requirements (academic degree, work experience, mandatory testing, program length) for the school year 2016-2017 throughout the United States.

**Methodology**

A predictive correlational design was used for this study. Archival data from all 50 U.S. states and the District of Columbia was collected and analyzed. Data used for this study was obtained from the Teacher Shortage Area (TSA) Nationwide Listing for 2016-2017. The listing was compiled by the U.S. Department of Education Office of Postsecondary Education and identified teacher shortages. The CTE certification/licensure requirements were collected from each state’s department of education either through their websites or through direct contact with the state’s certification/licensure agency. The study looked at each state’s alternative certification/licensure requirements for the academic degree, work experience, mandatory testing, and program length. Descriptive statistics can be viewed in Table 1.

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Shortage $(n = 32)$</th>
<th>No Shortage $(n = 19)$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academic degree</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>High School</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>Associates</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Bachelors</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Masters</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Work Experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-500 hours</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>501-3000 hours</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>3001-5000 hours</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>&gt;5001 hours</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td><strong>Mandatory Testing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not required</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Required</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td><strong>Program length</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;9 hours</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>10-18 hours</td>
<td>12</td>
<td>7</td>
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<tr>
<td>19-30 hours</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>&gt;31 hours</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

**Results**

The results of the binary logistic regression were not statistically significant, $\chi^2(8) = 14.04, p = .61$. The model had a medium effect size according to Cox and Snell’s $(R^2 = .029)$ and Nagelkerke’s $(R^2 = .039)$. Thus, the researcher failed to reject the null hypothesis that there is no significant relationship between the criterion variable (CTE teacher shortage) and the combination of predictor variables for CTE certification/licensure requirements (academic degree, work experience, mandatory testing, program length) for the school year 2016-2017 throughout the United States.
Conclusions

Studies have documented numerous issues with CTE, including teacher preparation program closures, teacher recruitment, retention, and certification/licensure requirements (Bartlett, 2012). Data from the Department of Education that shows interest in teaching down 5% since 2010 and enrolment in all teacher preparation programs down from 719,081 in 2008 to only 465,536 in 2014 (DiCarlo, 2015). Policy makers have attempted to change CTE teacher certification and licensure requirements to remedy the CTE shortage. However, the results of this study indicate that despite these changes, alternative routes to CTE teacher certification and the loosening of state policy requirements may have limited impact on combating the CTE teacher shortage. Educators may consider focusing on their efforts on teacher recruitment and retention as a means of addressing the CTE shortage. Many states have already begun reform efforts to implement base salary, performance pay or diversified pay.

Recommendations for Future Studies

1. A study that includes all the alternative pathways for each state. In 2007 there were 105 identified by the National Research Center for Career and Technical Education. The new study could address changes and trends in alternative pathways since 2007.

2. Research using qualitative methodology to address why business and industry professionals are choosing not to enter the CTE teacher profession. Because of a quantitative study does not allow the researcher to explore deeper into a question.

3. A study to describe and define the best practices in alternative CTE teacher pathways to be used as a model for consistency across the U.S.

References


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Kids Teaching Kids: A Guide for Working With a Chapter Team

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Introduction
Peer teaching is recognized in education as a viable strategy for student learning. The learning happens for the peer teacher as their knowledge is reinforced and for the student as their knowledge is set or developed. This method of teaching is recorded as early as Aristotle with his use of archons, or student leaders (Briggs, 2013; Henning, Weidner & Jones, 2006). The first recorded theory of peer tutoring is attributed to Andrew Bell in 1795 (Briggs, 2013). Bells approach paired tutors with tutees inside the classroom with the result of improving motivation and behavior of both (Burgess, 2011). This system was utilized in the early 19th Century throughout England. Recently it has been reintroduced into more widely practice.

Background of Technology Student Association
The Technology Student Association (TSA) is recognized by the U.S. Department of Education (2017) as “the only [Career and Technical] student organization devoted exclusively to the needs of technology education….”. TSA (2018) describes itself as “a national organization of student engaged in science, technology, engineering and mathematics (STEM).” With more than 250,000 middle and high school students involved in TSA the members participate in competitive events, leadership and social activities. Georgia Department of Education (2019) indicate students who are involved in Career and Technical Student Organizations develop core value:

- Commitment – To create among members, educators and business and industry an adherence and appreciation for all Career, Technical and Agricultural Education Programs.
- Conviction – To develop patriotism through knowledge of our nation’s heritage and practice of democracy.
- Education – To create enthusiasm and empower students to become lifelong learners.
- Integrity – To deal honestly and fairly with one another.
- Leadership – To develop leadership abilities through participation in educational, professional, community and social activities.
- Professionalism – To promote high standards in career ethics, workmanship, scholarship and safety.
- **Recognition** – Appreciation of the value of achievement.
- **Service** – To cultivate a desire to contribute to the benefit and welfare of others
- **Teamwork** – To enhance the ability of students to plan together, organize and carry out worthy activities and projects through the use of the democratic process (Georgia Department of Education, 2019).

These core values align with and support 21st Century Skill which are recognized as learning skills, literacy skills and life skill that contribute to student’s future careers (Applied Educational Systems, 2019).

The TSA competitive events (approximately 40 middle school events and 40 high school events) are correlated with *Standards for Technological Literacy* (2007); are co-curricular and/or extra-curricular activities. Because of the co-curricular nature of the competitive events many States recognize these as suggested activities for their state curriculum.

**Working with a Chapter Team**

When working with students it is best to have a plan with goals and/or objectives in mind (Wong & Wong, 1998). Having the students read the rules for the Chapter Team event provides them with an understanding and often stimulates questions. The teacher will need to honor their style of teaching regarding how much specific information they provide to the students or how they facilitate through suggestion and lead the students to locate important information. There is a sizable amount of information that each student will need to learn. Some students will choose to read together as they research while others will want to work on their own and return to the group and share their new knowledge. Still, group practice for this event is critical for all the pieces (i.e., knowledge, performance, knowhow) to come together.

**Peer Teaching**

Harry Wong (1998) indicated the importance of planning for instruction. A plan was developed by the author to assist the student teachers with their planning. It was then the students’ responsibility to plan for their student-to-student teaching session. After completion of the planning session wears for the teaching session were developed by students and some were provided by the teacher. The students then practiced their session and were prepared to teach.

The students prepared an agenda for their teaching session. They had collected a list of urls with viable information about Robert’s Rules of Order and saved them on a flash drive to share with their students. One site contained a Robert’s Rules of Order cheat and other sites contained quiz questions the students could utilize to drill and practice. The students retrieved the TSA rules for Chapter Team and provided electronic and printed copy for their students. The teacher provided the student teachers with eight (8) scenarios to share.

The student teachers were nervous at their first interaction with the younger students and were reminded to utilize their agenda and get to business where they quickly moved into action. The younger students were receptive and were excited to receive information. These students had several questions which the student teachers fielded with teenage vocabulary. After the presentation/demonstration and questions, the teaching students became engaged in the activities/competitive events of the younger students. The student teachers then became students of the younger teens as they inquired about their work.

This experience was limited yet powerful for the students involved. The older students reflected about growth of their skills as they prepared to teach and then actually made the presentation. They also reflected about things they had learned from the younger students. All indicated a positive experience and a willing to continue participation in the peer teaching activities.
Conclusion

Well planned peer teaching events can be rewarding for all involved. The student participating as the peer teachers will experience planning skills in a different way as they prepare their presentation and activities. They will utilize research skills to find information important for their lesson, organization skills to develop their agenda and wears, presentation skills to deliver their lesson, and listening skills to field questions and provide adequate response. The students receiving the treatment of the lesson will receive information from peers, often regarded as less formal and more desirable.

References


Preparation Students for TSA Middle School and High School System Control Technology

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Based on our experience as Technology Student Association (TSA) advisors, the Systems Control event was an underutilized event for our students and many others within our state of North Carolina. This is an issue particularly for large chapters as limited space is available in all events. Smaller chapters would also benefit from this event as it would allow students an opportunity to further their knowledge, deepen their skillset, and possibly win a trophy.

TSA is a Career and Technical Education Student Organization (CTSO) with more than 250,000 middle and high school students. TSA students enhance their classroom content with intracurricular competitive projects, during many of which they must work in a team consisting of their peers. All TSA competitions are written using Standards for Technological Literacy (STL) provided by the International Technology and Engineering Educators Association, ITEEA. (TSA 2019)

As students compete in over 60 various technology-based challenges, they also exercise various leadership skills while participating in TSA. TSA students utilize The Student Leadership Challenge (LEAP), which is broken into five practices of exemplary leadership. (John Wiley & Sons, Inc. 2013) These five practices are: Model the Way, Inspire a Shared Vision, Challenge the Process, Enable Others to Act, and Encourage the Heart.

System Control Technology is a team event for up to three members at the high school or middle school level. Students compete onsite at a regional, state, or national TSA conference. Students bring only a kit of materials as they have no prior knowledge to the challenge before the conference. The onsite problem challenges students to “develop a computer-controlled model-solution to a problem, typically one from an industrial setting.” (TSA 2018, p.275)

During the competitive session the students must create an autonomous computer controlled mechanical device that solves the problem within a time constraint. Students must provide documentation on how they utilized the design thinking process to create the solution, and instructions for a panel of judges to operate their device. The device is judged without any competitors in the room. (TSA, 2018, p.276)

This competition has an open-ended hardware aspect, students are required to bring their own materials to build their solutions. Many TSA chapters have these materials in their labs from other events such as robotics. Typical robotics systems include Vex Robotics, First Robotics, Fischer Technik and Lego Mindstorms. Each system has a various cost and skill requirements that should be evaluated by the advisors of a TSA program before purchasing.

For our TSA chapter Vex Robotics is a popular event that often has two to three times the interest than the available spots in the event. For this reason, we decided to utilize this population of students to teach others in System Control Technology.
TSA is defined as a CTSO, therefore it made sense for us as advisors to have students teaching students to place emphasis on the “student organization” portion of CTSO. Peer teaching is recognized in education as a viable strategy for student learning. The learning happens for the peer teacher as their knowledge is reinforced and for the student as their knowledge is set or developed. This method of teaching is recorded as early as Aristotle with his use of archons, or student leaders (Briggs, 2013; Henning, Weidner & Jones, 2006).

The robotics students have a prior understanding of how to program, build, and operate the brand of system the chapter uses for competitions. Often during the robotics season many larger parts are trimmed down to meet size requirements of the robot build. These spare parts could quickly grow into a kit useful for the system control technology competition.

The peer-teaching model could be adjusted from inside of a TSA chapter to chapters helping chapters. This approach would best be fit for a group of high school peers to teach a group of middle school peers that would ultimately feed into the high school chapter.

In this model the author provided the students with an industrial challenge adapted from the Technology Engineering and Design (TED) curriculum. The high school students competed in the challenge after school on an afternoon, then later in the week brought the challenge to the middle school students to solve. According to Harry Wong (1988) planning for instruction is essential. As advisors we set the high school students up for a successful teaching moment by having them brainstorm a plan of work for the middle school students to follow that included processes and tasks the high school students found most difficult under a time constraint.

We have found that this model gives the high school students various LEAP skills and opportunities needed as TSA members, but it also prepares them for another TSA competition that is underutilized: Future Technology and Engineering Teacher. The Future Technology and Engineering Teacher event allows students the opportunity to explore technology curriculum concepts and test their skills as teachers. (TSA, 2018, p.201)

References


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Incorporating STEM in Middle School Intervention Courses

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Abstract:

Middle school mathematics intervention courses can have adverse effects on the development of student identity and positive dispositions to mathematics. These concerns prompted me to engage in a self-study of my teaching practices when I was assigned such a course at the beginning of the 2018-2019 school year. My classroom of seventh graders had a total of ten students - all from minoritized backgrounds typically underrepresented in the STEM community. As a male mathematics teacher of African descent, I am acutely aware of the challenges of underrepresentation and the questions of identity that might cause students to underperform academically. Therefore, desiring change, I developed a curriculum for the course that incorporated a partnership that I developed with a local museum which emphasized hands-on and project-based STEM learning experiences. As the school year proceeded, I reflected on my teaching practices and the effects that they had on the shifts of my students as they engaged in the course material. Data collected included records from personal journals and audio/video of my teaching practice. Analysis of the data resulted in a better understanding of how the incorporation of technology and engineering practices enable students to see themselves as part of a “community of practice” where mathematics is meaningful and necessary for improving their everyday lives. The results are informative for practitioners looking to develop curricula that provide students opportunities to strengthen their mathematical identity and agency.

Context

In the United States, the failure to successfully complete mathematics courses that are considered to be prerequisites for later courses, such as high school algebra, can provide an insurmountable barrier for students, particularly those from low-income and minority backgrounds, to successfully pursue careers in the STEM community (Morales-Chicas & Agger, 2017). Therefore, school divisions have begun to employ an increasingly popular strategy, especially in urban middle schools made up of low-income and minority students, to provide a “double-dosing” of mathematics to help students prepare for those courses (Cortes, Nomi, & Goodman, 2013) and the high stakes exams that occur before them. It may seem obvious that it would be beneficial to provide students with additional mathematical learning opportunities to help them catch up with their more proficient classmates. However, critics of this strategy suggest that the psychological effects, including loss of student confidence and the likelihood that these classes will be filled with minoritized children who have been separated from their classmates and deemed in “need of intervention,” will outweigh any possible benefits (Howard, Romero, Scott, & Saddler, 2015). Research suggests that remedial mathematics programs that focus solely on student achievement but ignore student identity, agency, and interest are unlikely to succeed (Gutierrez, 2011). While achievement is obviously important, care must be taken to attend to the entire spectrum of factors that affect student performance in school. “Real-world” activities can have a meaningful impact on students who have traditionally underperformed in mathematics. This can take the form of project-based learning or design-based tasks (National Research Council, 2011). Problem-based technology and engineering challenges provide opportunities for STEM learning in interesting and relevant contexts and integrative
approaches can help make abstract concepts in mathematics more readily accessible for students (Becker & Park, 2011)

**Purpose**

This ongoing study, then, seeks to investigate the following questions.

1. In what ways does my incorporation of technology and engineering hands-on and project-based learning modules support the development of student mathematical identity and agency in a classroom setting?

2. What are the challenges of implementing this curriculum?

**Theoretical Framework**

The supplemental coursework for “double-dosed” courses in my school division were overly test-focused and not much different from what students might receive in their regular classrooms. Teachers were provided with workbooks which contained seemingly endless examples of problems which could be found on the year-end high stakes exams. Students lacked interest in completing the workbooks and I had even less interest in teaching from them. As a current classroom teacher and doctoral student, I feel fortunate to have feet planted simultaneously in the worlds of research and practice. I decided to use self-study research methodology to evaluate my development of this program because I wanted to develop a better understanding of the social world of my classroom (Samaras, Frank, Williams, Christopher, & Rodick, 2016). The purpose of self-study research is to generate knowledge (Kosnick, Beck, Freese, & Samaras, 2005) and this process will hopefully provide me with a framework to revise the educational program of my classes to maximize the development of mathematical identity and agency.

**Methods**

For the 2018-2019 school year, students will have the opportunity to visit a local museum six times during the school day as part of their regular classroom instruction. At the museum, students will participate in a STEM-based workshop that provides students opportunities to incorporate the mathematics learned in the school environment with hands-on learning activities that require creative and critical thinking. As the students participate in this workshop, I will be recording my observations and reflections in journal form during each visit. Video and audio recordings of my teaching will be made during this time. I will also use assessments of student understandings in the classroom and the museum to reflect upon my perception of their development of mathematical identity and agency.

**Initial Findings/Results**

By taking students out of the school setting and pairing them with knowledgeable “others,” these integrated mathematics lessons can engage students and help them understand how technological and engineering practices fit into their identities as learners and community members. Students need to see themselves as legitimate participants in a community of practice (Barton & Tan, 2010). During our initial visit, students expressed surprise that they would even be allowed to participate in such an activity. The museum has the appearance of a science laboratory and when we entered, one student blurted out that “they are going to throw our black a---- out of here.” Of course, I assured him that the program had been previously arranged. Later, as I reflected upon his comments, I thought about the type of identity threat that might have spurred his concerns. This student, perhaps jokingly, believed that there was a possible conflict between who he was as a person of African descent and the possibility of being an effective student and participant in a laboratory-type setting. It helped me recognize that while the traditional responsibilities of being a mathematics teacher may very well remain, practitioners who seek to increase student participation and performance in STEM activities need to be aware of and have strategies to deal with student
perceptions of threats to their individual identities. Therefore, coursework and classroom practice need to be intentional in welcoming and attending to student identity.

The museum activities provided students with opportunities to work with a very diverse group of instructors who challenged them to develop technological and/or engineering solutions to problems that students felt needed to be addressed in their communities. Students designed, for example, rockets that would help rebuild the ozone layer, toilet facilities that would keep the environment clean, and cars that ran on clean solar power. To be sure, there was some resistance to working on activities at times and that was occasionally linked to a lack of math skills that was a source of frustration for students at times. While I tried to anticipate the specific seventh grade mathematical skills (i.e., proportions) that students might use in their designs, it was not always possible to anticipate all the skills from a previous grade level that might be needed for a task as students improvised. Future iterations of these lessons may also need to emphasize a greater range of mathematical standards for above and below the grade level.

**Conclusion**

From my initial findings, students who are deemed in "need of remediation" at the middle school level risk being permanently alienated from the STEM community. Intervention classes at the middle school level, while well-intentioned, create the perception of incompetence at a fragile time in the lives of students. Teachers should continue to investigate how the integration of engineering and technological makerspaces can support the development of student proficiency and competence in the mathematical classroom.

**References**


**Acknowledgements**

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Increasing STEM Awareness in Underrepresented Populations – Actualizing STEM Potential in the Mississippi Delta

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Introduction

This project will advance efforts of the Innovative Technology Experiences for Students and Teachers (ITEST) program to better understand and promote practices that increase students’ motivations and capacities to pursue careers in fields of science, technology, engineering, or mathematics (STEM) by investigating the effectiveness of an existing collaborative robotics program. The program will positively influence the engineering self-efficacy and orientation to STEM majors with African American students living in an underserved region of the United States, the Mississippi Delta. Students in this program are immersed in engineering design activities requiring the application of science and mathematics principles. The program model includes pre-engineering courses in computer science, computer-aided drafting, and electronics.

Methodology

This longitudinal mixed methods research study is designed to investigate the influence of engineering design and career orientation activities implemented in a collaborative robotics/pre-engineering program on African American students' self-efficacy, and scientific identity, to better understand factors influencing their achievement in STEM disciplines and orientation to STEM majors. This is a four year study, allowing the researchers to follow a group of students from freshman to the end of their senior year, so that key factors influencing the students' learning and achievement in the engineering course activities can be observed and documented during the peak years of decision making for college majors and careers.

Context

This study is unique in terms of its location and population of students and because it is longitudinal and utilizes a mixed methods approach. While this study investigates the effectiveness of the program on the engineering self-efficacy, scientific identity and achievement of program objectives for students in this program, the findings of the study could also be valuable for informing initiatives devoted to increasing the numbers of students from other marginalized groups majoring in STEM fields. Quantitatively, this research employs pre and post measures to determine changes in students engineering self-efficacy and scientific identities. Qualitatively, field notes from classroom observations and interviews with the high school students provide data on specific program elements determined to be effective in positively influencing the African American students’ achievement of program objectives and decisions to pursue STEM careers.

The State of Mississippi consistently ranks at or near the bottom of the list of states in several categories including employment, health, and education. It is one of the most poverty stricken of all 50 states. There are many dismal statistics endemic to the State, and more particularly the Delta. Census Bureau (U.S. Census Bureau, 2017) and the Bureau of Labor Statistics (U.S. Department of Labor, 2018) for Sunflower County Mississippi report: Per capita income = $14,427 per year; Poverty rate 36.2% (89.5% of black population in poverty...
vs. 8.9% of white population); 47.5% of population in the civilian workforce (52.0% of females in workforce); Decline in high wage jobs since 1990 = 54%; Households without a car = 12%; Access to health care among worst in the nation - 29 primary care physicians per 100,000 people, 30 dentists per 100,000, 11 mental health professionals per 100,000; and education is consistently at or near last place among all states: 8th grade NAEP proficiency = 21.4% in math, 20.0% in reading; Adults with at least a Bachelor's degree = 21.8%.

Population and program details

This study proposed to attempt to replicate a successful program in western Virginia in the Mississippi Delta. The "carrot" or the physical manifestation of STEM instruction was participation in the FIRST Robotics Challenge (FRC), an international high school robotics competition. Each year, teams of high school students, coaches, and mentors work during a six-week period to build game-playing robots that weigh up to 125 pounds. Robots complete tasks such as scoring balls into goals, flying discs into goals, inner tubes onto racks, hanging on bars, and balancing robots on balance beams. The game, along with the required set of tasks, changes annually. While teams are given a standard set of parts, they are also allowed a budget and are encouraged to buy or make specialized parts.

FIRST Robotics Competition has a unique culture built around two core values: Gracious professionalism embraces the competition inherent in the program but rejects trash talk and chest thumping while embracing empathy and respect for other teams. “Coopertition” (cooperation and competition) emphasizes that teams can cooperate and compete at the same time. The goal of the program is to inspire students to be science and technology leaders.

2018 was the 29th year of the competition. 3,647 teams with more than 91,000 students and 25,000 mentors from 27 countries built robots. They competed in 63 Regional Competitions, 85 District Qualifying Competitions, and 10 District Championships. In addition to on-field competition, teams and team members competed for awards recognizing entrepreneurship, creativity, engineering, industrial design, safety, controls, media, quality, and exemplifying the core values of the program. 3,647 teams from 28 countries competed in 2018 Power Up. Of these, 3,171 are "veteran teams" (meaning they have competed in previous seasons), and 476 are "rookie teams" (meaning that 2018 was their first season of competition) (First, 2018).

In 1999 a group of high school students in Montgomery County, Virginia formed a partnership with the School of Education at Virginia Tech to start a FIRST Robotics team. “Copperhead Robotics” (Team 401) has grown and found great success over 19 seasons! Copperhead Robotics student members earn high school credit for participating with the team while working with engineering students from Virginia Tech. The Virginia Tech Schools of Education and Mechanical Engineering offer senior level courses allowing college mentors to earn credit for helping the team. This successful program is the template for the underrepresented population in Mississippi.

The Mississippi team is based at Gentry High School in Indianola, Mississippi where they meet to design and build their robot. Students at nearby Mississippi Valley State University, a Historically Black College (HBCU), serve as mentors for the high school students. Three faculty members from MVSU provide additional support in the areas of Drafting and Design, Electronics, and Computer Programming. Each of these faculty teach a two week "module" in their specialty at the high school during the fall semester, prior to the six-week "build season" in January and February each year. Mississippi Valley State University students can enroll in an Internship course and receive 3 hours of college credit in exchange for participating as mentors for high school students.
Findings

Preliminary data indicate that the intervention is making a difference among the population. University mentors have demonstrated growth in their technical ability, their understanding of STEM occupations and in their leadership capacity. High school students have demonstrated similar growth. High school graduates who have participated in the program for two or three years may have a better understanding of STEM occupations and appear to consider STEM programs when evaluating college programs to attend.

The community has benefitted from the program in aspects that are difficult to quantify. The nature of the program encourages partnerships within the school and across the community. Each year the program has become more successful so momentum is growing. The “target” group of freshmen have just completed their fourth year in the program so the data are still being compiled and analyzed. Early results are encouraging!

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References


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Validating Industry Recognized Credentials

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Introduction

The term “Industry Recognized Credential” was introduced in the 2006 reauthorization of the Carl D. Perkins Act (Perkins IV). The term was coined as a means of ensuring that Federal funds allocated to state programs were being utilized efficiently. Intuitively, it makes sense that if students are awarded an industry recognized credential they must have attained quality training and skills that reflect quality instruction and programs.

Even though "Industry Recognized Credentials" is mentioned numerous times in Perkins IV (and Perkins V), it is not defined. The United States Department of Labor (2010) defines an industry recognized credential as: An education-and work-related credential can be defined as a verification of an individual’s qualification or competence issued by a third party with the relevant authority to issue such credentials. Various types of credentials (certificate, certification, license, and degree) are defined by the Association for Career and Technical Education (ACTE, n.d.).

The presentation at the 2019 International Technology and Engineering Educators Association meeting provided a brief history of the Perkins Act, the explosion in industry recognized credential vendors after the term was introduced in 2006, a case study in the drafting industry, a case study in mechatronics/advanced manufacturing at Patrick Henry Community College, and suggestions for selecting and validating local credentials.

Types of Recognized Credentials

An education and work-related credential encompasses educational certificates, degrees, certifications, and government-issued licenses:

Certificates are awarded upon the successful completion of a brief course of study, usually one year or less but at times longer, primarily in public or private two-year institutions of higher education, university extension programs or non-degree granting postsecondary institutions like area career and technical education schools. Upon completion of a course of study, a certificate does not require any further action to retain.

Certifications indicate mastery of or competency in specific knowledge, skills or processes that can be measured against a set of accepted standards. These are not tied to a specific educational program, but are typically awarded through assessment and validation of skills in cooperation with a business, trade association or other industry group. After attaining a certification, individuals often must meet ongoing requirements to maintain the currency of the certification.

A license is legal permission, typically granted by a government agency, to allow an individual to perform certain regulated tasks or occupations. A license can be obtained by meeting certain requirements set forth by the licensor, usually by completing a course of education and/or assessments. Upon receipt of a license, ongoing requirements may be necessary to maintain the license.
An academic degree is an award or title conferred upon an individual for the completion of a program or courses of study over multiple years at postsecondary education institutions (ACTE, n.d.).

Federal Funding and Accountability

Federal funding of Career and Technical Education programs is tied to the various iterations of the Carl D. Perkins Act. Funding is important to any program and providers of these programs must comply with provisions imposed by the fund granting entity. The government must ensure that any funds provided to CTE result in positive outcomes. The Perkins Act aims to make certain that there is an adequate return on investment for federal dollars.

Page 9 of the Perkins Act of 2006: The Official Guide (2006) published by the Association of Career and Technical Education states, “At the post-secondary level, academic attainment will no longer have to be reported as a separate measure, but like the secondary level, technical skill proficiency should include student achievement on technical assessments that are aligned with industry recognized standards when possible.”

The goal here was to provide a tangible, reliable and quantifiable means for the assessment of CTE programs. Section 3 of Perkins IV (United States, 2006) defines Career and Technical Education: The term ‘career and technical education’ means organized educational activities that –

(A) Offer a sequence of courses that-

(i) provides individuals with coherent and rigorous content aligned with challenging academic standards and relevant technical knowledge and skills needed to prepare for further education and careers in current or emerging professions

(ii) provides technical skill proficiency, an industry recognized credential, a certificate or an associate degree

It is important to note that an industry recognized credential is but one of several means of assessing CTE courses. It is also important to understand that many “industries” have no single or central recognized credentialing body. Computer Aided Drafting and Design (CADD) is one such example. Drafting is a diverse occupation used in many engineering endeavors: Aeronautical, Architectural, Civil, and Mechanical to name a few. The industry is not served by one common body. This leaves “certification” open for anyone to provide, including self-certification.

Just prior to the ITEEA Conference in 2019 self certification became a topic of great interest as related to the Boeing Corporation and the Federal Aviation Administration (FAA). With two major aircraft crashes within months of one another, aircraft safety was in the headlines of many news outlets. Who was responsible for the safety of airplanes used by the flying public?

The ultimate authority belonged to the FAA. However, the agency apparently does not have the recourses to adequately perform all of the aircraft safety inspection duties required of it. The FAA evidently ceded much of its responsibility for aircraft inspection to the manufacturer of the aircraft. Boeing was, in fact, inspecting its own work.

There are parallels in this example to many industries, including drafting. After 2006 almost every provider of drafting software introduced or expanded their “credentialing” platforms. This manufactured demand provided an additional revenue stream for software developers to certify users of the software as competent with the software. Many times this certification is relevant only to the software and not necessarily to the industry.
Third-party credentialing groups amped up their marketing of credentialing. One example is NOCTI who purports to be “the largest provider of industry-based credentials and partner industry certifications for CTE programs across the nation. Whether using assessments to meet Perkins accountability requirements, to guide data-driven instructional improvement, or to assist with teacher evaluation systems, NOCTI provides a credible solution through its validated and reliable technical skill assessment” (NOCTI, 2019). The American Design Drafting Association (ADDA) is a group that provides third party certification dedicated specifically to the drafting industry (American Design Drafting Association, 2019).

Case Studies
The author conducted research in 2011 to determine the attributes that employers of community college drafting graduates desired in new hires. There were examples of drafting skills mentioned (dimensioning, auxiliary views, etc.) as well as soft skills (working well as part of a team, time management, etc.). Interestingly there was not a single mention of any industry recognized credential (Trent, 2011). The author has performed “spot checks” of employment websites (Indeed.com for example) for the occupation of “drafter” and has yet to find a trend – or a single example of certification being a requirement employers seek when hiring drafters.

Patrick Henry Community College, working with industry partners and grants from Appalachian Power Company and the Harvest Foundation developed their own certification program. This Industry 4.0 Festo Leader College curriculum has awarded 135 student certifications across three levels of Siemens Mechatronic Systems Certification. The community partnership developed Career Studies Certification in partnership with Eastman Chemical (CSC Advanced Film Manufacturing – 28 hour academic credential) and Manufacturing Skills Standard Certified Production Technician (MSSC) (Festo.com, n.d.).

Conclusions
The Perkins Act of 2006 sought to ensure accountability for federal dollars allocated to Career and Technical Education programs. In an effort to find a fast and reliable means of quantifying the quality of programs consuming these funds the term “Industry Recognized Credential” was coined with the assumption that students who received a credential recognized by industry must have received superior training. Introduction of this term led to a manufactured demand for credentials and there was a minor explosion in the availability of credentials. The quality, reliability and validity of these credentials vary widely. One must carefully select the credential(s) to be used to validate instruction. Some are much better than others. Alternatively, one may choose to develop a local certification in partnership with industries within the service area of the institution where training is provided. Providing credentials desired or required by employers (consumers of CTE graduates) is essential.

References