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ABSTRACT

The purpose of this study was to describe a process of preparing technology education teachers to teach engineering design concepts in the context of technology education. This process was identified through a study of professional development activities that were organized and conducted by technology teacher education partner universities of the National Center for Engineering and Technology Education (NCETE) to prepare middle school and high school technology teachers to infuse engineering design, problem solving, content, and analytical skills into the K-12 curriculum. A collective multisite case study formed the methodology for this study. Data were collected through individual interview sessions that lasted 30-40 minutes, video footage, observations and artifacts. A total of 15 interviews were individually analyzed, and then compared through a cross-case analysis. Professional development emerged as a core theme and comprised the following sub themes: planning, communities of practice, professional development administration and learning environment, professional development for technology education teachers, professional development activities in the classroom, assessment, expertise, and meaning making.

INTRODUCTION

Humankind during the past century has experienced unprecedented change in every aspect of life. Knowledge is growing at an astounding rate with new technological innovations and scientific data accumulating on a daily basis. Global competition in the business world, the Internet, and widespread use of technology continue to create new challenges and opportunities for employers and workers. Gomez (2000) postulated that the lack of technically-oriented individuals is one of the most significant labor shortages during such dynamic times. Consequently, this has posed a great challenge for technology teacher educators endeavoring to prepare teachers who will be responsive to a rapidly changing workplace and the global economy as a whole.

Future development of technology education curricula will be influenced by changes in the social, economic, political, and technological forces shaping each and every sector of our lives. Jobs in the 21st century, particularly those involving new technologies, will need team players, problem solvers, and people who are flexible and possess high levels of interaction skills. According to Leask (2001) these rapid technological changes illustrate the necessity for regular review of technology education curricula, and a need to constantly upgrade teachers' knowledge and skills. Teaching today presents a progressively multifaceted work environment that requires continued professional development. What teachers teach and what they are prepared to teach should reflect the times in which they live.

Previous research has reported the challenges of continuously preparing career and technical education teachers (Lynch, 1990, 1997; McCaslin & Parks, 2002; National Center for Career and Technical Education [NCCTE], 2001; Walter & Gray, 2002). A report on the status of career and technical education teacher preparation programs by the National Center for Career and Technical Education (2001) identified discrepancies between teacher preparation, practice, and professional development. Teachers often have too few opportunities to improve their knowledge and skills, and their professional development opportunities are of poor quality. The U.S. Department of Education (1998) acknowledges that professional development activities serve as the bridge between where prospective and experienced educators are now, and where they will need to be, in order to meet new challenges of guiding all students in achieving higher standards of learning and development.

Currently, the field of technology education stands at a critical juncture in its history. Custer (personal communication, April 8, 2005) stated that while some very positive initiatives have taken place in the field, a number of critical problems still facing the profession must be addressed for the discipline to survive and thrive. In the same vein, Clark (1989) postulated that technology education is in crisis, largely caused by the increasing changes that are occurring within society and technology.

Ritz (1992) argued that there was much confusion in the field about what technology education was and what students in technology education programs should be learning. Israel (1992) identified the importance of developing a multifaceted curriculum that depicts the versatile nature and scope of technology education. Zuga (1999), Rowell (1999), and Cajas (2000) each stated that there is a great deal of research to be conducted in determining efficient and cost-effective ways to conduct professional development activities that would support teachers as they continuously improve their capacity to help their students become technologically literate.

There is keen interest in identifying curricular and teacher instructional practices that are effective in accomplishing technology education goals. Experts in the field of technology education have identified engineering as a professional field that is, closely associated with technology and strives to solve modern societal problems that have practical importance. This perspective therefore, places engineering as a field most closely associated with technology education.

To attend to these challenges and expose students to engineering design concepts, secondary technology teachers and university professors will need to collaborate through engineering design workshops. The National Center for Engineering and Technology Education (NCETE) has proposed that the field of technology education adopt aspects of an interpretation of design based on the engineering definition. The center has advocated infusing engineering design as a focus for technology education curriculum as a reasonable strategy to address the concerns of the field (NCETE, 2005).

Based on needs identified in the literature, this study investigated the content and instructional practices of teacher educators facilitating engineering design activities at selected NCETE sites. The study also examined secondary technology teachers' reflections on their experiences with respect to content, delivery, strengths, and weaknesses of engineering design workshops at selected NCETE sites.

PURPOSE

The purpose of this study was to describe a process of preparing technology education teachers to teach engineering design concepts in the context of technology education. This process was identified through professional development workshops administered by teacher educators at two National Center for Engineering and Technology Education (NCETE) sites. The study identified and proposed recommendations for developing, implementing, and conducting professional development workshops for teacher educators who prepare technology education teachers to teach engineering design concepts within the context of secondary technology education. The investigation was guided by the following research questions (a) How are the two sites similar or different? (b) What factors influence teacher educators' choice of content and instructional activities when conducting engineering design professional development workshops? (c) What theories of instruction and learning do teacher educators use to teach engineering design in professional development workshops? What influenced them to choose these theories? (d) How do teacher educators conducting professional development workshops plan to evaluate the effectiveness of the workshops in meeting stated objectives? (e) What reflections concerning their experiences with respect to content, delivery methods, strengths, and weaknesses of the engineering design workshops do secondary technology teachers have? What are the strengths and limitations of each program? (f) What would secondary technology teachers like to have changed in engineering design professional development workshops with regard to content and instructional activities? Why would they like the changes? and (g) What implications for subsequent programs can be drawn from data collected at the two sites?

METHOD

This study assumed that, (a) knowledge is constructed through social interaction, (b) professional development workshop activities consist of a group of people with similar goals, insights and thoughts, and (c) professional development workshop activities assist in the development of a common approach to solve educational challenges among a group of people who share similar practices. Therefore, a qualitative case study approach was chosen to describe a process for preparing technology education teachers to teach engineering design concepts in the context of technology education. The case study approach was selected for several reasons.

Firstly, Merriam (1998) and Bogdan and Biklen (1998) postulated that case study research seeks to understand specific issues and problems of practice through a detailed examination of a specific group of people, a particular organization, or a selected activity. In this study, the researcher's sought to understand faculty best practices and experiences of participating secondary technology teachers. Secondly, it was important that I actually see and understand the content, instructional practices and interactions that occurred between teacher educators and secondary technology teachers in the workshops. Therefore, this approach to the study allowed the participants to relate their individual perspectives toward and experiences of engineering design professional workshop activities, as well as describe their distinctive practices.

The social context of teacher preparation activities and learning influence the ways preservice and inservice teachers construct new knowledge. Thus a social constructivist theoretical framework guided this multisite case study of two NCETE sites involved in teacher professional development activities. Teachers' interaction and participation in their communities' cultural and professional activities facilitate acquisition of new knowledge through practical experiences. Constructivist and communities of practice perspectives recognize individuals as active agents in the construction of their knowledge Constructivism and communities of practice frameworks were chosen to guide the researcher to interpret participant's perceptions (Lavoie & Roth, 2001).

PARTICIPANT SELECTION

Merriam (1998) stated that non probability sampling was the method of choice in qualitative case studies. For this study convenience sampling was used to select participants. Two reasons supported the decision to employ a convenience sample. First, the number of workshop participants at the study sites differed considerably since they were being offered over the summer. Second, workshop scheduling and administration of the programs were being conducted at different locations and by different personnel. It was important to coordinate with personnel at these sites to select study participants. Participants included secondary technology teachers and educators who participated in and completed engineering design professional development workshops during the summer of 2006 at two National Center Consortia Universities. Fifteen participants were interviewed. Two were females, and thirteen were male. Four of the participants were university professors whose area of specialization is teacher preparation in technology education and engineering design practices. The remaining eleven participants were middle and high school teachers, eight of whom taught at the high school level and the other three at middle school.

DATA COLLECTION

Data collection took place over the summer of 2006 at both centers and consisted of daylong observations, video footage of workshop participants completing design challenge, 30-40 minutes of interview session, and artifacts. Interview transcripts were transcribed verbatim in October 2006 and sent out to workshop participants for member checks. The researchers divided the transcripts into two groups, workshop facilitators and workshop participants.

DATA ANALYSIS

Data analysis began with the first interview of each group as described by, Miles and Huberman (1984) and Goetz and Preissle (1984). Each individual analysis was then followed by a cross-case examination of data as described by Merriam (1998). The researchers bracketed participants’ responses by becoming aware of prejudices, viewpoints, and assumptions regarding professional development activities and teacher preparation. This helped them conduct the analysis from a fresh and open viewpoint without prejudgment or imposing meaning too soon. In other words, the researchers placed participants' stories in the foreground and moved my theoretical frameworks and biases to the background. Taking this position informed their understanding of participants' experiences without presupposing already held beliefs and my own experiences.

The 15 interviews were analyzed separately using some grounded theory strategies and inductive analysis. Each transcript was read with an open mind so that data could be approached without preconceptions about engineering design professional development activities in technology education and a general feeling could be developed regarding each participant's experiences. The researchers also spent several hours watching and replaying the video footage looking for data and instances that supported my emerging themes. This process helped them to identify expressions relevant to participants' experiences regarding professional development engineering activities, suggestions, and concerns as they tried to make meaning of the data. To keep on discovering anything new in the data and gain a deeper understanding of what the concepts we have identified stand for; Strauss and Corbin (1990) stated that we must conduct a detailed and discriminate type of analysis referred to as micro analysis. This form of analysis uses the procedures of comparative analysis, asking of questions and makes use of analytic tools to break data apart and dig beneath the surface.

The researchers grouped data which they found to be related in meaning into categories, events and interactions. Next, the researchers embarked on reducing repetitive meaning units to eliminate redundancy. Hycner (1985) pointed out that it was important to note the actual number of times a unit of relevant meaning was listed since that might indicate some significance as to how important that particular experience was to the participants. This iterative procedure helped refine any initial categories identified, redefining them and fitting data into perceived categories. This process also facilitated comparison of data from interview transcripts within and from each site. Charmaz (2002) stated that after deciding which categories best explained what is happening in the study, grounded theorists treat these categories as concepts that seek to explain the phenomenon of interest.

DISCUSSION AND FINDINGS

Participant responses and additional material collected during the study led the researchers to categorize these data according to the commonalities and themes that emerged with no observed priority or order. Professional development emerged as a core theme and comprised the following sub themes: (a) planning, (b) communities of practice, (c) professional development administration and learning environment, (d) professional development for technology education teachers, (e) professional development workshop activities for the classroom, (f) assessment, (g) expertise, and (h) meaning making. Participants names have been changed to pseudonyms and quotes are used throughout this section to emphasize identified themes.

Professional Development

NCETE seeks to increase the number and diversity of students who select engineering, science, mathematics and technology careers (NCETE, 2005). Teaming engineering faculty and technology educators in a synergistic approach to facilitate professional development sessions for secondary technology teachers based on testing, adaptation, and adoption of instructional techniques that enhance science, technology, engineering and mathematics (STEM) at the K 12 level is seen as vehicle to accomplish this overarching goal. According to Palinscar, Magnusson, Marano, Ford, and Brown (1998) professional development of teachers meant improvement geared to their classroom practice, that is, planning, enactment, and reflection upon instruction for the purpose of helping children learn. Therefore, professional development is a means by which teachers acquire and enhance a set of skills and knowledge in order to meet new challenges of guiding all students in achieving higher standards of learning and development.

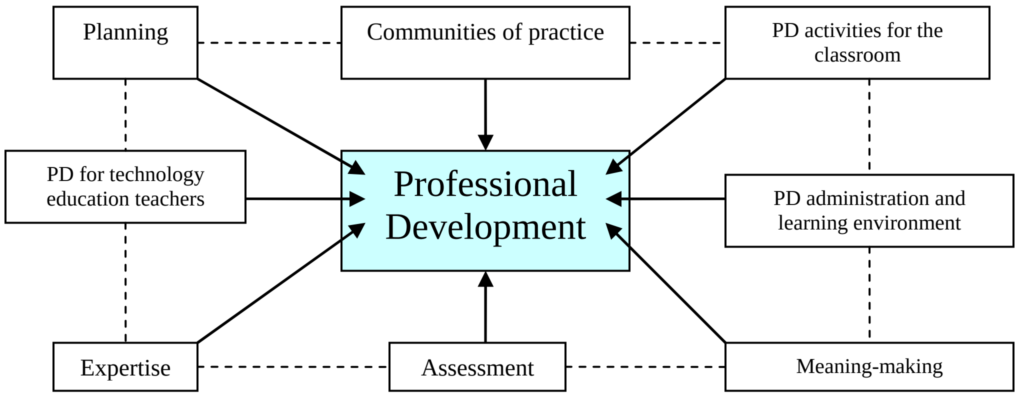
In this study professional development meant several things to the participants. First, it referred to providing teachers with an additional tool, or to improve some form of expertise they already possessed to enable them be more effective and efficient in performing their work related duties in the face of change. Barno remarked, “It’s finding a new way to do something to hopefully be more effective in the classroom with students.” Kicheko postulated, “professional development is something that allowed an individual to extend their potential, it’s the thing that the life long learner will seek out as a professional.” Petro argued that professional development mirrored inservice and was a way of providing teachers with new teaching tools after they had entered the profession.

To most secondary technology teachers who participated in this study professional development referred to learning something new that they could help make a connection to what they were already doing in their classroom. Visupu a high school teacher reported that the workshop was a success. With regard to the professional development workshop activity, she said, “I can use it with my students I may not do it the same way in my class but I will definitely use it with my students.” Moko a middle school teacher reported that the hands-on activities in the workshop were very important experiences for kids, since they learned by seeing.

In this study, for an engineering professional development workshop to be successfully administered, the following components were viewed to play an integral role (a) planning, (b) communities of practice, (c) professional development administration and learning environment, (d) professional development for technology education teachers, (e) professional development activities in the classroom, (f) assessment, (g) expertise, and (h) meaning-making.

Figure one below depicts a graphical representation of the elements that should constitute professional development workshop activities as described by the participants in this study.

Figure 1. Components of professional development as described by participants of this study



Planning

As documented on the NCETE website, the organization seeks to use professional development as a vehicle to (a) develop secondary technology teachers' instructional decision making so that it focuses on the analytical nature of design and problem solving needed to deliver technological as well as engineering concepts, and (b) develop engineering analysis and design skills in technology teachers, strengthening their mathematics and science knowledge and skills.

Dillon-Peterson (1986) stated that effective long term change result most often in relation to an effective planning process rather than in relation to isolated miscellaneous short term activities. To achieve instructional changes of delivery of technology education material at the K-12 level, workshop facilitators strategically planned to conduct engineering professional development over a period of five years, with each year divided into three main workshop segments. The centers have agreed to conduct and facilitate the first segment of the workshop session during the spring semester, followed by a summer session and finally the last segment is conducted during the fall and early winter. It can therefore be argued that having a formal system of doing things that realizes a desired goal can be referred to as a plan.

Petro a workshop facilitator who has been teaching for over thirty years said, "You know, a lot of times you can make all sorts of excuses when things backfire, but if you had a plan you feel better prepared to enter into certain situations." A plan can therefore, be thought of as a well devised guiding strategy that highlights procedures or a course of action that will lead to the realization of intended objectives. According to Barno a workshop facilitator, as soon as the summer segment is concluded workshop facilitators at Eleven University seek feedback on suggestions for improvement in readiness to plan for the next group of teachers. Barno stated:

> We will start thinking of what workshop activities we need to change and how, what materials they will need to order, what teachers will need to accomplish tasks presented to them, how many teachers will be invited to attend and how many will be middle school or high school.

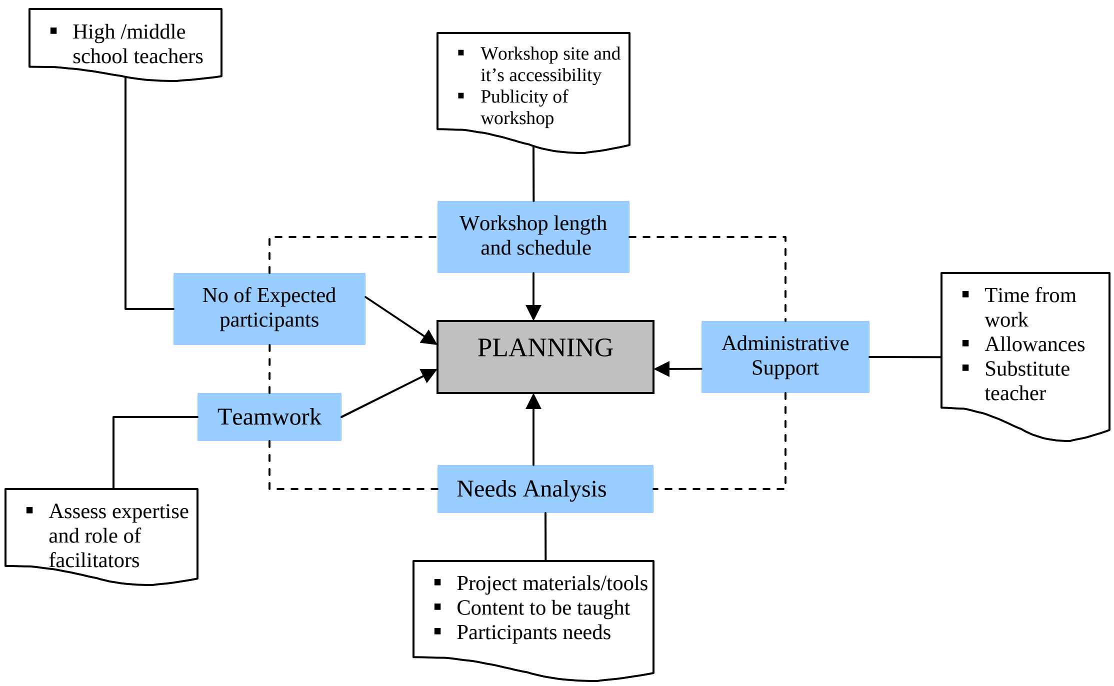
Figure two depicts a graphical representation of elements that go into planning an engineering design professional development workshop as identified in this study. These elements are not limiting and individuals should reflect and conduct a needs analysis before embarking on planning similar professional development workshops.

Communities of Practice

Communities of practice a concept fronted by Wenger (1998) espouses that learning is explored through the intersection of community, social practice, meaning, and identity creation. Wenger (2004) described communities as groups of people who share a concern or a passion for something they do, and who interact regularly to learn how to do it better. In this study, a group of teachers and workshop facilitators who shared a common goal met and participated in engineering design workshop.

Harifa, a high school teacher who had been teaching for 15 years thought the workshop provided an opportunity to sit and talk with other teachers about different ideas regarding how they could implement different projects in their classrooms.

Figure 2. Elements of planning that embrace engineering design professional development workshops as identified in this study.



This is what Harifa said:

> Even though, we may get away from the concept of engineering design, one is still learning. You're learning what was successful in your class, what wasn't. He may tell me something that was successful in his class, and I may take that to my class next year. So, we share ideas, because the bottom line is we're all in here for one general purpose, the kids. What can we do to help each other out to all get to that common goal?

Petro one of the workshop facilitators summed up the idea of communities of practice when he said:

> By the time we get to year 4, we are going to have more seasoned people giving advice to people who are taking this for the first time. Also, because we're trying to focus on high schools that are planning on small learning communities.

Such workshops present teachers with an opportunity to work together in teams, building coherent learning experiences for themselves and their students. As people work together to analyze what is working and to solve problems, they develop the ability to see how the whole and its parts interact with each other.

Professional Development Administration and Learning Environment

Successful facilitation of professional development requires management of all the components that constitute its operation. Lockwood (1991) stated that administration and management of professional development programs called for expertise, effective planning, creation of a favorable learning environment, information flow between stakeholders, administrative support from school system, feedback from the workshop facilitators and regular opportunities to discuss ideas, experiences and encountered problems.

In this study, the two sites had similar managerial styles and operations. Barno said that his team realized that they had their limitations and did not have all the answers neither did they try to figure out all possible solutions to activities they had prepared before conducting the workshops. He stated that his colleagues were committed to supporting the participants and offer guidance to facilitate learning. This is what he said, “We left it to them to build the models, and we are here for support if they get to far off. We are learning quite a bit also at the same time.”

On the other hand participants in this study unanimously agreed the learning environment created by the workshop facilitators was befitting for the workshop. Moko remarked:

> I really don’t feel out of place, it’s very relaxed and you can move around the shop. The tendency is that if you are comfortable in your environment you are freer to make good decisions and if you feel out of place then you going to be pressured to make decisions.

The informal contextual learning environment created in these workshops, the support structure accorded by workshop facilitators in addition to time off from work, provided a setting in which participants' negotiated meaning and socially constructed knowledge as they sought to solve presented challenges working in a team.

Professional Development for Technology Education Teachers

Professional growth in education is considered as a process of change in teachers' mental models, beliefs, and perceptions with regard to children's learning and cognitive abilities. (Mevarech, 1995). Borko and Putnam (1995) stated that professional development programs that focus on expanding and elaborating teacher's knowledge systems are vital in today's climate of educational reform.

Limpo described some activities his team conducted to meet this objective, he mentioned that they tried to incorporate a lot of different things, for example they invited key speakers, took field trips, conducted group work, and hands-on activities. Additionally he said, "We give them problems to work on individually. There are some homework assignments they take back and reflect on, we provide them with reading assignments so that they can learn more about the topics we do."

Petro stated that his main goal was to specifically teach workshop participants how to conduct engineering design challenges in their classroom. He also expected them to develop a plan for integrating these activities in to their program. Barno echoed Petro's thoughts when he said, "we are not necessarily giving teachers new content, its more about enhancing technology education lessons and putting in the engineering design." According to Kicheko a workshop facilitator, the summer workshop was a transitional phase from theory to practice. In other words it was time for participants to put into application what they had learned over the spring segment of the workshop. Kicheko remarked, "What they're doing this week is what they should be teaching to their students. It is essentially a rehearsal of how to conduct this kind of activities in their classrooms."

When asked if the workshop had exposed him to strategies that he will use to transfer knowledge he had acquired in the workshop to his classroom setting**,** Mitaro a high school teachers said:

> I think that the workshop did try to focus on that issue, particularly in the second half of the workshop. They spent more time talking about what issues we will face in adapting this design challenge into our classroom curriculum. In my case, it fits very naturally into my robotics curriculum. But, for other people, it wasn't as close of a fit.

Benta, a math high school teacher had a different opinion. He remarked, "I knew everything already, so it was kind of…., I wouldn't say, a waste, but it was redundant." Contrary to Benta's view, Mitaro commented that one of the things that the workshop did really well, was making sure that teachers from a wide range of backgrounds were presented with all the knowledge they needed to participate before they embarked on the design challenge. He said, "We spent a lot of time working on background knowledge and information, while my background is engineering, I still enjoyed everything."

The statements by Mitaro and Benta, mirror Sayer (1996) thoughts when he stated that successful professional development programs should recognize the expression of differences in teachers' opinion, values and feelings. Based on the expectations and suggestions of workshop participants, workshop planners need to conduct analysis and find how prospective participants were prepared to be teachers, their background knowledge, needs, and expectations of workshop material beforehand. Professional development for technology teachers that's geared to infusing engineering content in to the curriculum should be guided by a clear set of goals, mission, and plan. Prospective workshop participants should be provided with relevant workshop information ahead of time.

Professional Development Workshop Activities for the Classroom

Today, teachers seek professional development sessions that refine their conceptual and crafts skills, guide their teaching practices and are related to daily classroom activities (Tallerico, 2005; Guskey & Huberman, 1995). Professional development activities designed to help teachers infuse aspects of engineering design in to the K-12 level should be designed to promote team work, meeting of minds and a state of engagement that will be rewarding to individuals. Brown, et al. (1989) argued that the activity in which knowledge is developed and deployed is not separable from learning and cognition. In other words, learning and cognition may be fundamentally situated in an activity.

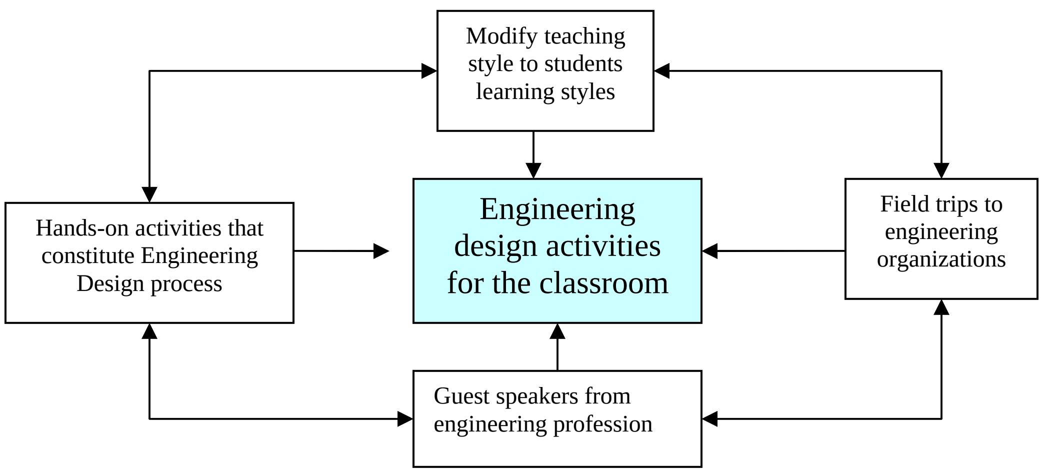
In this study, instructions were sequentially ordered to provide participants with prerequisite knowledge to complete assigned challenges. Limpo pointed to this when he said, “we give them all the requisite knowledge that they will need to know for the engineering design challenge that happens in the summer.” Petro further espoused Limpo’s statement. He said:

> Because some of our teachers are from professions other than tech ed, it's a new exposure to things like project-based learning. The whole series of spring workshops is foundation laying. They come out of these sessions well-prepared to take on the engineering design challenge that we provide for them.

According to Block (1994), developing lessons that assist students to become better problem solvers should strive to (a) build student’s commitment, (b) increase their engagement in difficult thinking processes, (c) develop their self-efficacy, (d) decrease their tendencies toward learned helplessness, (e) resolve their cognitive dissonance, and (f) increase their personal problem- space. This study identified that the key to infusing K-12 technology education curriculum with engineering content is developing classroom activities that reflect engineering design concepts while reflecting on Block’s (1994) factors. These activities should be designed to consist of lectures, demonstrations and hands-on activities that constitute the engineering design process, field trips to engineering schools, and motivational key speakers. Additionally, teachers should seek to understand their students learning styles as such as those described by Kolb (1984).

Figure three depicts components that complete infusion of engineering design activities for the classroom as described by participants of this study. Each of these components plays an integral role and should be taken into consideration when designing and implementing engineering design activities for the classroom.

Figure 3. Elements that play a role in successive implementation of engineering design activities in the classroom.



Expertise

To be effective in incorporating aspects of engineering design in to the K-12 curriculum, teachers must know the required subject matter so thoroughly that they can present it in a challenging, clear, and compelling way. Consequently, the nature of engineering design professional development workshops should be designed to expose participants to develop some expertise in terms of the theoretical aspects as well as practical application of knowledge and skills. According to Berliner (1994) expert teachers know the cognitive abilities of the students they teach regularly. This gives them insight for determining the level at which to teach. In other words expert teachers use knowledge about their students learning abilities and design lessons that connect ideas to students' experiences. They diagnose sources of problems in students' learning and how to identify strengths on which to develop and build a wide variety of learning opportunities for students employing different learning styles. In other words an expert teacher is one who possesses some level of proficiency that enables them to create an environment that nurtures learning.

It was observed that participants of this study perceived workshop experiences as basis for improving their teaching practices with regard to engineering design infusion into technology education. Virtually all participants of this study stated in one way or another that the workshop would benefit their student's knowledge base. Thande a middle school teacher commented, "I know right now by the end of the year I will have tweaked my projects enough to where I can take what my students are doing now and incorporate what I have learned here."

Moko stated:

> I think am going to take those rural kids and move them towards the high school faster and further and then knowing my counterpart at high school knowing who he is and what he is doing we both are going to say we going to have the best Tech Ed program in our county. I am able to go further and I know its going to help my kids and that's the biggest part.

Meaning-Making

In this study meaning making is portrayed in different ways. To solve the design challenge presented, participants needed to make meaning of required task and negotiate among themselves probable solutions. This was portrayed when Moko said, "Blake would come up and say we need to do this, but how? And I was like, am I going to fabricate it based upon what we have here?" Tembo a high school teacher exclaimed, "I was the documentation manager and most of the time I was like wait a minute we have to get this done … okay we got that done, now we need to shift gears and get this piece done." Thus workshop participants negotiated their thoughts and made meaning of opinions presented in their teamwork activities to solve design challenge presented.

Assessment

The last concept to emerge from the data was assessment. Assessing professional development and its impact is a long term goal which Barno termed as, "work in process and should be done on a continual basis." In this study, workshop facilitators at both sites agreed that they were not out to assess how successfully the participants mastered and completed the design challenge but how successful they implemented engineering design concepts into their curriculum as well as teach.

Petro commented, "Yes, we do assess how well they master the design challenge. It's not significant. It's only done so that they have a sense of feedback. What we want is 6 teachers that can go out and touch 100, 150 students a year."

Barno reported:

> We want them to experience some success with their projects and mentally get them to accept the value of engineering design and what it can bring to their classroom. It's opening them to do things in a new way, adding new things to the existing curriculum. If they do that and make a strategic effort to get the kids to do more predictive analysis, optimization and try put that structure into their classroom and we can go back in later and observe them exposing kids to these concepts. That is really what we are after.

This study therefore, portrays assessment procedures as a conduit that provides an opportunity for both workshop participants and facilitators to continuously improve, remedy professional development programs, and build upon the skills they have acquired and already possess to effectively and efficiently perform their teaching activities. In other words, assessment is envisioned as an incessant activity that seeks to challenge workshop participants' to succeed in implementation of engineering design concepts in their classrooms and K-12 curriculum

How Results Address the Research Questions and Purpose of the Study

The findings reveal practical approaches to teaching engineering design aspects to teachers and brings to light secondary teachers' and workshop facilitators' reflections, and opinions that could help enhance efforts to infuse engineering design as a focus for preparing technology education teachers as well as related classroom activities. Due to the nature of qualitative design, these findings are not generalizable to a larger population and do not imply any priority with regard to the way they have been listed. The following findings summarize what the researchers learned from this study:

1. Professional development has different definitions
2. Project based learning is a powerful way to conduct engineering professional development workshop activities geared to help infusion of engineering aspects into technology education.
3. To meet stated objectives, professional development requires commitment from facilitators and participants as well.
4. Professional development workshops that seek to infuse engineering design aspects into the K-12 technology education curriculum are enhanced when communities of practice and collaborative learning strategies are utilized.
5. Engineering professional development activities for secondary technology teachers is guided by the interplay of the following components (a) successful planning (b) professional development administration and learning environment that exhibit communities of practice attributes (c) meeting professional development needs and expectations of technology education teachers (d) a set of activities that are transferable to the classroom setting and depict infusion of

engineering design into technology education curriculum (e) a feedback system, and (f) subject matter experts who exhibit expertise in administration and facilitation of teacher preparation activities as well as engineering and technology disciplines.

6. Workshop facilitators should guide participants to finding solutions to design problems presented, through strategies like reflective analysis, global before local, sequencing, lectures etc.
7. Professional development engineering design activities situated in a contextual environment may help students to be actively engaged and view learning as relevant to meaningful real world problems, learn from each other, and develop high order thinking and problem solving skills as evidenced by the comments of workshop participants in this study.
8. Individuals undertake professional development for various personal and professional needs depending on where they are in their careers.
9. According to the participants of this study engineering design activities meant for the classroom should seek to exhibit the following components (a) hands-on activities that constitute engineering design processes (b) field trips to engineering organizations (c) engineering profession motivational speakers, and (d) modification of instructional practices and use of a wide variety of strategies that support students' learning techniques.
10. Figure 4 depicts a graphical representation of a process that can be undertaken to develop, administer, and evaluate professional development workshops that seek to infuse aspects of engineering design into the K-12 level technology education curriculum

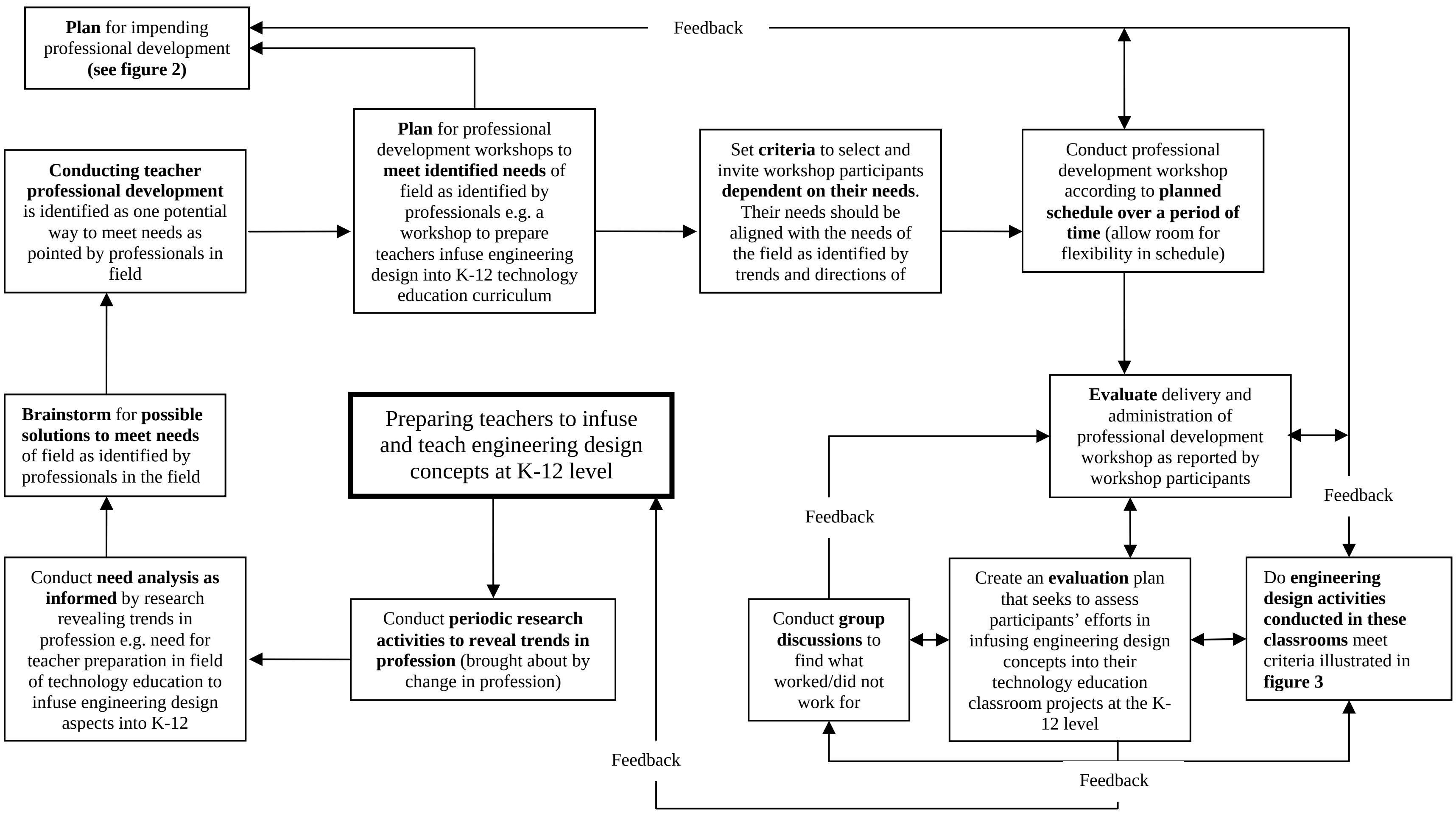
as described by the participants of this study. This process is not limiting and individuals may modify the steps to suit their needs. It is imperative that when performing each of the steps as described in the process, one needs to stops and reflects on the whole process upon finishing a given step, and then goes back to the very beginning for clarity. This process is not linear; rather it is broken into distinct structured steps or activities that call for careful planning, team work, and accessibility to vast resources. To interpret this process, start at the bolded rectangle and follow directions of the arrows.

IMPLICATIONS

Implications of this study apply to (a) teacher educators who prepare secondary teachers as well as prepare and deliver professional development workshops and are actively involved in engineering and technology education, policy makers and administrators, and (b) middle and high school teachers interested in integrating engineering design into their classroom teaching

Implications for Teachers Educators, policy makers and administrators. A major implication for practice will be the process identified for preparing technology education teachers to infuse aspects of engineering design into the K-12 technology education curriculum. This process is graphically presented and outlines ingredients and key components that teacher educators need to reflect on when designing professional development activities geared to infuse engineering design into the context of technology education. These components are not limiting in that, they offer a reference point from which teacher educators can design workshops of such magnitude. Specifically this process requires educators to conduct periodic research activities that determine needs and the projected direction in the field of technology education in order to prepare programs that will continuously meet any impending changes.

Figure 4. A process for preparing technology education teachers' to infuse aspects of engineering design into K-12 technology education curriculum as described by participants in this study.



Built into this process should be reports on suggestions and feedback from workshop participants with reference to workshop content, teaching strategies, and general administration of the workshop. This study calls for greater collaborative efforts among stakeholders, that is, NCETE, policy makers, teacher educators, and administrators involved in preparing inservice teachers who can infuse engineering design aspects into the K-12 curriculum. Such efforts are longitudinal in nature and need to be the cornerstone of technology education teacher preparation practices. These inservice education programs should be all-year round activities for teachers with evaluative practices in place. This means that procedures ought to be established to have teacher educators involved in engineering and technology education conduct inservice education at the state level throughout the year. To this end, school administrators should offer incentives and support structures for teachers who seek to attend workshops of this nature. Additionally, if infusion of engineering design at the K-12 level is the way forward for technology education each state education department should seek to develop an organizational structure, personnel and strategies that will seek to support such an endeavor.

At the pre-service level, policy makers, engineering and technology education teacher educators, and administrators need to strategize, collaborate, and seek ways to develop and deliver programs that are interdisciplinary and offer aspects of engineering design at the university level. Such programs should be designed to encourage the participation of students from engineering, math, science, and technology education. This venture will not only create broader rich learning experiences for these students but also meet the long term objective of infusing engineering design at the K-12 curriculum.

Implications for Middle and High School Teachers Nearly all teachers stated their reasons for attending the workshop; for example, one main reason these teachers indicated was that they liked the hands-on activities in the workshop and looked forward to incorporating engineering design aspects into their technology education classes. Having participated in the workshops, participant's experiences, suggestions, and practices might influence and offer middle and high school teachers a better understanding of the importance of engineering design and the significant role it can play when incorporated in the curriculum. The study also draws attention to characteristics of design challenges that seek to exhibit engineering design aspects in the K-12 classroom.

Future Research

1. A similar study should be conducted in the three remaining NCETE centers on the perceptions and reactions of technology education educators and teachers toward workshop content
2. Conduct follow-up study to find out how workshop participants implement engineering design aspects into their classroom activities.
3. Conduct a study that seeks to find out the reaction and perceptions of workshop participants' students with regard to their experiences with engineering design infusion into their classroom activities.

Conclusion

For infusion of engineering design to be successfully integrated in the K-12 level curriculum, there needs to be a systematic and yet flexible approach that includes the components identified in this study. Such an approach should be informed by policy makers, teacher educators, school administrators, and the wider community by actively supporting such ventures through participation in research studies that seek to find out more on how we can improve teacher preparation practices as well as curriculum materials.

Developing such practices not only emphasizes the concerns and research needs as reported by experts in the field of technology education, but also lays a foundation for innovative curricular changes, and program design while providing an ideal platform to re-examine the objectives of infusing engineering design into the K-12 curriculum. It is hoped that this study will help improve facilitation of engineering design activities and pave the way for future research that seeks to address infusion of engineering design at the K-12 level. Such a venture may bring about curriculum changes that depict integration of technology education, engineering, and other subjects that offer broad learning experiences and are focused on using a systematic process to develop logical solutions within the constraints of the environment and society.

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