A MULTISITE CASE STUDY OF FACULTY AND TEACHER PERCEPTIONS OF NCETE PROFESSIONAL DEVELOPMENT WORKSHOPS ON ENGINEERING DESIGN CONTENT

by

PAUL ANDEKA ASUNDA

(Under the Direction of Roger B. Hill)

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, to look for emerging themes. 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.

INDEX WORDS: Professional development, Communities of practice, Professional development administration, Professional Development learning environment, Expertise, Meaning-making, Assessment.

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"I can do all things through Christ, who strengthens me" (Philippians 4:13).

The Lord has accomplished what concerns me; his loving kindness has been everlasting. Lord, do not forsake the works of my hands; continue molding me as I do your work. I give thanks to You forever for this great accomplishment, and all the things You have in store for me.

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Everything I am or hope to be I owe to God.

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CHAPTER I

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 Research 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.

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. O'Riley (1996) pointed out that in some places technology education has been construed as a separate subject for study, and in others it is seen as an emphasis to be included in all subject areas across the curriculum. Thus, Lewis (1999) stated that the relationship of technology education to other subjects in the curriculum was a fruitful area of inquiry. He posited that it was imperative to establish whether integration of technology education with other subjects helped to improve student learning of technological concepts and processes.

Proceedings from the first and second American Association for the Advancement of Science (AAAS) Technology Education research conferences highlighted several key areas in need of research in the field 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. In the same vein, Loepp (1999) called for research on professional development, curriculum development, implementation, and evaluation in technology education.

In order to encourage advancements in programs, one of the thrusts has been to identify and highlight exemplary practices. Zuga and Bjorkquist (1989) argued that such practices would be those that are representative of advanced technology and are fixated to the modern life. 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 this end, 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).

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 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.

There is keen interest in identifying curricular and teacher instructional practices that are effective in accomplishing technology education goals. Bell (1991) and Holly and Mcloughlin (1989) stated that professional development was and still is the most common and widely accepted approach to the development of teachers' instructional practices. Professional teacher preparation workshops are highly valuable and need to be ongoing, interactive, and should be enhanced to be supportive for teachers. Henry (1999) stated that workshops provide crucial opportunities for teachers to examine personal beliefs in the actual classroom context and to evaluate those beliefs, eventually reinforcing, adapting, or rejecting them.

According to Bruner (1990) an individual's way of life revolved around shared meanings and beliefs as well as shared modes of discourse for negotiating differences in meaning and interpretation. It would then follow that previous experiences such as workshop activities and practices affect the way individuals perceive, respond to and construct meaning from new information and hence gain an understanding of the world around them. Thus, examining teacher educators' practices and technology education teachers' experiences toward professional development activities will provide useful guidance for educators in preparing future workshops and providing instruction for preservice teachers. 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 Statement

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. This study 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.

Specific objectives of the study were to (a) investigate the content, methodology and instructional practices of teacher educators facilitating engineering design workshops at selected NCETE sites, and (b) document secondary technology teachers' reflections on their experiences with respect to content, delivery methods, strengths, and weaknesses of engineering design professional development activities at two NCETE sites.

This was a multisite case study of teacher educators' experiences and accounts of their practices in designing and implementing engineering design professional workshops at two National Center Consortia Universities: Eleven University and Twelve University.

The study was guided by the following research questions:

1. How are the two sites similar or different?
2. What factors influence teacher educators' choice of content and instructional activities when conducting engineering design professional development workshops?

3. What theories of instruction and learning do teacher educators use to teach engineering design in professional development workshops? What influences teacher educators' choice of theories?
4. How do teacher educators conducting professional development workshops evaluate the effectiveness of the workshops in meeting stated objectives?
5. What are the reflections of secondary technology teachers' experiences with respect to content, delivery methods, strengths, and weaknesses of the engineering design workshops? What do secondary technology teachers say are the strengths and limitations of each program?
6. What would secondary technology teachers like to have changed in engineering design professional development workshops with regard to content and instructional activities? What are the reasons for the changes?
7. What implications for subsequent programs can be drawn from data collected at the two sites?

Theoretical Frameworks

Two theoretical frameworks are combined to guide this study, each contributing important perspectives from which to establish the design, analysis, and interpretation of data. These theoretical traditions are: (a) constructivism, and (b) communities of practice.

Constructivism

Constructivists argue that, what individuals take to be objective knowledge and truth is the result of perspective. In other words, knowledge and truth are created and not discovered by the mind (Schwandt, 1998). According to Von Glaserfeld (1995), knowledge is a collection of ideas and actions that one has found to be successful in a particular situation. Bruner (1990) posited that our way of life revolves around shared meanings and ideas as well as shared modes of discourse for negotiating differences in meaning and interpretation. Jarvis (1992) pointed out that every experience about which individuals reflect is perceived through all the learning embedded in their funds of knowledge as a result of previous experiences. Brooks and Brooks (1999) postulated that each individual made sense of the world by synthesizing new experiences into what had been previously understood. Thus, it can be argued that no experience is isolated from previous ones, and this affects the way individuals perceive and respond to situations. Fosnot (1996) referred to this process as constructivism, a perspective that describes what knowing is and how one comes to know.

Constructivism is the view that all knowledge, and therefore all meaningful reality, is contingent on human behavior, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context. Meaning is not discovered, but rather constructed (Crotty, 1998). Doolittle and Camp (1999) pointed out that constructivism acknowledges the learner's active role in the personal creation of knowledge, the importance of experience in this knowledge creation process, and the realization that knowledge created will vary in its degree of validity as an accurate representation of reality.

Von Glaserfeld (1998) proposed three essential epistemological beliefs of constructivism, including (a) knowledge is not passively accumulated, but a result of active cognitive processes by an individual, (b) cognition is an adaptive process functioning to make an individual's behavior more viable given a particular environment, and (c) cognition organizes and makes sense of one's experience and is not a process of rendering an accurate presentation of reality. Schwandt (1998) stated that inferences derived from constructivist framework are shaped by the intent of their users. He posited that constructivists share the goal of understanding the complex world of lived experience from the point of view of those who live it. In other words, constructivism provided a framework for meaning making and it can be assumed that people construct their own knowledge and an understanding of the world from their experiences and interactions with others. In this study, it is believed that teacher educators and middle and high school technology teachers are likely to construct and make meaning of knowledge about teaching and learning based on their workshop experiences.

Communities of Practice

Jean Lave and Etienne Wenger coined the term communities of practice to describe what they researched in studying apprenticeship as a learning model (Lave & Wenger, 1991; Wenger, 2004). According to Wenger (1998) communities of practice presents a theory of learning that assumes that engagement in social practice is the fundamental process by which people learn and so become who they are. The primary unit of analysis is neither the individual nor social institutions but rather the informal “communities of practice” that people form as they pursue shared enterprises over time. This theory explores, in a systematic way, the intersection of issues of community, social practice, meaning, and identity.

Wenger (2004) stated that communities of practice are groups of people sharing a concern or a passion for something they are doing, and who learn how to do it better as they interact regularly. He further argued that, not everything called a community is a community of practice. For example, people living in the same neighborhood often form a community, but it is usually not a community of practice. Wenger postulated that for a community of practice to grow and exist, three characteristics are crucial: a domain, a community, and a practice.

The domain. According to Wenger, a community of practice has an identity defined by a shared domain of interest. To belong to such a group, an individual should show commitment to the domain, and therefore a shared competence that distinguishes members from other people.

The community. Wenger posited that members of a given domain engage in joint activities and discussions, help each other, and share information in pursuing their interests as they build relationships enabling them to learn from each other. Wenger argued that a website in itself is not a community of practice, and that neither having the same job nor the same title makes for a community of practice unless members interact and learn together.

The practice. Members of a community of practice are practitioners. They develop a shared repertoire of resources, that is, experiences, stories, tools, and ways of addressing recurring problems.

Based on constructivism and communities of practice theories and their role in learning and meaning making, it can be argued that knowledge is constructed. Therefore participants' perceptions in this study were their thoughts and beliefs about events that they encountered as they participated in engineering design workshops.

Significance of Study

It is anticipated that this study will enhance efforts to infuse engineering design in the curriculum as a focus for preparing technology education teachers. The study contributes to a deeper understanding of the conduct of engineering design professional development activities in technology education. Secondary technology teachers' reflections toward engineering design content and their experiences will immensely shape future instructional planning in addition to creating a framework that may help restructuring inservice professional workshops for technology teachers. It is expected that findings and recommendations outlined by the researcher will help secondary teachers understand the importance of engineering design activities at the K-12 curriculum level. Strategies that teacher educators use to design, implement and administer engineering design content in the context of technology education in engineering design-focused professional development workshops are described. This may yield practical approaches that will assist and benefit those who organize and conduct systematic professional development as well as classroom activities related to technology and engineering. Additionally, findings of the study will support ongoing scholarship work in the field of technology education teacher education and professional development.

Summary

In this section I have provided background information on the focus of this study: a process of preparing technology education teachers to prepare a workforce that can adapt to the changes in our environment. Engineering design professional development workshops have been identified as a vehicle to meet this need. To this end, a purpose statement, research questions that address this concern in the context of engineering design professional development workshops, theoretical frameworks that will guide this inquiry and a discussion on the possible impacts the study may have to the field of technology education are presented.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

The field of technology education has been in a constant state of flux and reorientation since its inception in secondary schools. This chapter summarizes literature related to history of technology education and provides a concise description of how the field has evolved over the years, including teacher preparation activities. Foundational research in the two theoretical areas that will guide this study, constructivism, and communities of practice are also addressed.

Cultural Development and the History of Technology Education

The human society has evolved through the Paleolithic period, Agricultural Civilization, Bronze Age, Middle ages, Renaissance and Reformation period to the present world, thriving on scientific innovations, technological and engineering practices that better the lives of its people (Scott & Sarkees-Wircenski, 2004). Early man learned to fabricate sharper implements from flint, construct wooden boats, domesticate animals, manufacture pottery, produce grain and live in communities. Man thrived on communal manual labor and continued to make progress through this mode of work developing civilizations based on scientific knowledge, government and religion in the valleys of Nile, the Tigris and the Euphrates rivers (Roberts, 1965).

According to Finch (1961) the story of human civilization depicts increased use and emphasis on human intelligence, interaction and improvement of crude tools to transfer physical labor from human shoulders onto machines. Jackson (1933) stated that agricultural practices devised by early man developed into a vocation that led to production of simple machines to aid in cultivation (for, example, drawing water from wells, a tradition practiced by early Egyptians) and preparation of its products. Jackson further stated that such machines may have included winnowing and grinding machines which were crude but were improved over the years as opportunities for, and the utility of inventions increased with growing population and the advancement of civilization. Thus, through agricultural revolution, vocational education took root very early in the history of mankind (Hawkins, Prosser & Wright, 1951). Prosser and Allen (1925) defined vocational education as a series of controlled and organized experiences used to prepare individuals for any given employment.

In late 1700s and early 1800s, the Swiss educator Johann Heinrich Pestalozzi developed a system of educational theory and practice from which vocational education borrowed heavily during its formative years. Pestalozzi's ideas influenced developments in vocational education and saw learning taking place in the form of apprenticeship, children learned by doing (Scott & Sarkees-Wircenski, 2004). Thus, early educators were constantly looking for ways to connect school with work as they continually sought to prepare their students through apprenticeship programs and other instructional practices that would help students acquire the necessary skills to operate and be productive in early industries.

Apprenticeship implied learning a trade under someone who was considered to be a master in the said field. Scott and Sarkees-Wircenski (2004) described apprenticeship as one of the oldest methods of formal instruction that is still used to prepare workers in the building trades, and a variety of other trades. With the coming of the industrial revolution, new inventions and processes were developed requiring the society to adapt to these new systems in order to function in a changing environment. Thus, use of apprenticeship as a training method declined as these new invention and processes did not require much training.

From Manual Training to Technology Education

From late 1800s to the present society, technology education as a discipline has transitioned through methodological and philosophical changes that strive to meet the changes of a dynamic technological society as well as keep pace with current waves of industrialization and societal needs (Dearing & Daugherty, 2004). According to Cochran (1970) curricular patterns of many variations developed rapidly as early efforts toward manual training programs at the collegiate and high school levels were initiated. Such programs were based on a theory of formal discipline which stressed educating the mind through the hands, developing the powers of observation through the senses, and instilling an appreciation for the dignity of labor. Foremost of these programs were the manual training school established by Calvin M. Woodward in St. Louis, and the School of Mechanic Arts founded and developed by John D. Runkle at the Massachusetts Institute of Technology. Since then, the field has adopted different names, from manual training, industrial arts, and later technology education, in a quest to reflect the practices of the discipline, changing times, and the technological status of society.

Manual training as a program was conceived in 1880 by John D. Runkle, president of the Massachusetts Institute of Technology and Calvin M. Woodward a professor of mathematics and applied mechanics at Washington University in St. Louis, Missouri. Runkle discovered that engineering education could be made more practical through teaching of manual techniques. He argued that manual education was essential if schools were to respond adequately to industrialism. Woodward echoed Runkle's thoughts, he saw the need for combining shop-work and academic courses for secondary school students as a means of supplementing liberal education with manual activity. He stated that such a program would keep boys out of mischief both in and out of school while helping them choose a vocation. Further Woodward suggested that a combination of manual and mental activities would improve educational programs of all prospective workers and produce intelligent citizens (Lazerson & Grubb, 1974; Roberts, 1965; Woodward, 1890).

Manual training was misunderstood and thought of differently by many educators. Some saw it as a means for making traditional subjects more practical; others claimed it served as pre-vocational education, supplying general vocational preparation for artisan occupations by teaching skills common to many of them. Calvin M. Woodward, John Dewey and others opposed to specialized vocational education did their best to dissociate manual training from programs of trade training. The fact that it was not intended to prepare individuals for skilled work or any other type of occupation, it was resented by those promoting vocational education. Those interested in vocational education insisted that to be vocational, the curriculum must include training that leads directly to a specific and recognized occupation (Leighbody, 1972).

According to Scott and Sarkees-Wircenski (2004) John D. Runkle and Calvin M. Woodward's vision of manual training did not last long due to the wide variety of programs that sprang up under the name of manual training. In addition, some educators of the time argued that manual training exercises did not result into useful products and hardly captured the American youth (Roberts, 1965). As industrialization set in with the turn of the century, the most basic problem facing manual education was its failure to prepare skilled individuals to operate machinery. Lazerson and Grubb (1974) pointed out that the economy did not need individuals who understood traditional crafts and principles of production, but those who could operate industrial machines, supervise assembly lines, and organize corporations. Thus, there arose constant pressure to make manual training more vocational to prepare youth for industrial jobs.

The manual arts movement remained the dominant force well into the 1930s, but new directions provided by John Dewey, Charles Russell Richards, and others caused some industrial educators to experiment in other directions (Cochran, 1970). As early as 1904, Charles Russell Richards the director of the department of manual training at Teachers College, Columbia University drew attention to a change in name for the field. He argued that it was evident that fundamental changes in attitudes toward the proper content and aim of constructive work had developed. Hence, manual training was not fully expressing the meaning of school handiwork, and was thus misleading as an indication of the aim and character of work. Charles Russell Richards suggested the name industrial arts, arguing that this term indicated a definite field of subject matter. Griffith (1912) argued that manual training had failed to lead forth powers of the child to the fullest extent, it had failed to take into account the reflective phase of interest. As industry became the dominant influence in the economy, industrial arts as a term and subject became vital in schools. Therefore, to adjust to job situations, and subsequently a vocation and changes in lifestyle brought by industrial revolution, individuals were required to have knowledge of tools, materials, processes, productive capacity, and relationships of industry (Roberts, 1965). Scott and Sarkees-Wircenski (2004) stated that industrial arts was seen as a discipline of study with manufacturing industries as the curriculum base and an understanding of the functioning of the industrial society as the goal.

Hawkins, et al. (1951) stated that industrial arts as a subject bounced between manual training and the engineering college. Bonser and Mossman (1924) defined industrial arts as a study of changes made by man in the forms of materials to increase their values, and of the problems of life related to these changes. They postulated that there were two kinds of study of industrial arts: the vocational and the general educative purpose. The vocational aspect consisted of studies for the sake of developing skills and efficiency for producing in a particular industry. General educative included studying materials, processes, conditions of production of important industries and how these processes affected one's everyday life. Most educators during this period believed that industrial arts contributed to the general education of youth, rather than providing merely vocational job entry skills (Dugger & Yung, 1995).

Roberts (1965) stated that industrial arts was viewed as a discipline that would foster development of a strong foundation in skills, knowledge and attitudes related to various aspects of the American industry. This was to be accomplished by planning industrial arts curriculum to include many activities and experiences related to industrial problems and processes, thus helping youth choose a vocation.

In 1907, an organized movement for federal aid for industrial education gained momentum. The movement started in an attempt to provide additional funds for industrial arts courses in agricultural and urban high schools. This movement set the stage for the passage in 1917 of the Smith-Hughes Act and other federal vocational legislation that followed (Cochran, 1970). Over the years, the practice and direction of vocational education, likewise industrial arts has constantly been changing since the signing of the Smith-Hughes Act of 1917 among other Acts such as the, George-Reed Act of 1929, George-Ellzey Act of 1934, George- Deen Act of 1936, George-Barden Act of 1946, National Defense Education Act (NDEA) of 1958, Vocational Education Act of 1963 and 1968, and reauthorization of Carl D. Perkins vocational education Act of 1984 (Roberts,1965; Scott & Sarkees-Wircenski, 2004).

During the 1930s to late 1960s, industrial arts consisted of instructional shop work which provided general education experiences centered on present day industrial and technical life. Those participating in industrial arts programs received orientation in the area of appreciation, production, consumption and recreation through actual experiences in planning, producing, servicing and repairing various types of consumer goods in common usage (Roberts, 1965). With the launch of Russia launched Sputnik 1 into space in 1957, America's standing in technical and scientific fields was in question. In 1958 congress recognized the importance of mathematics, science, foreign languages and other technical occupations by passage of the National Defense Education Act (NDEA) which focused on post secondary education (Scott & Sarkees-Wircenski, 2004). Cochran (1970) stated that, the 1960s produced wide changing implications on industrial arts curriculum. Acting on the impetus provided by the "Sputnik" influence, new frontiers began to emerge. Technological developments, automation, and other economic factors focused attention on providing students with a wider range of experiences, programs to meet life needs, and activities directed at an understanding of society.

Lewis and Zuga (2005) stated that late 1950s and early 1970s proposals focusing on technology began to appear with the intention of moving industrial arts curriculum from handicrafts to technology with suggested course work in management, communications, construction, power, transportation and manufacturing. Lewis and Zuga posited that this period witnessed growing discomfort among some industrial arts educators who believed that the discipline was not reflecting changes in technological innovations nor was it representative of modern technology. Thus, some educators in the discipline began planning, implementing and experimenting with news ways of teaching industrial arts. This period of curriculum debate lasted until 1980s when a team of industrial supervisors from the state of West Virginia created a scheme they called the Jackson Mill Curriculum Theory.

In 1982 the Jackson Mill Model was introduced as the main benchmark for industrial arts teaching. This model revolved around four universal systems: communication, construction, manufacturing and transportation. Early 1990s saw the International Technology Education Association (ITEA) update the Jackson Mill Model and identify four universal content areas: bio-related, communications, production and transportation. These areas were to be used to guide technology education instruction (O'Riley, 1996). In 2000, the ITEA after consulting with teachers and experts in the field developed and presented a document entitled, *Standards for Technological Literacy: Content for the Study of Technology* (Lewis & Zuga, 2005). These standards outlined and defined what students should achieve and be able to perform as they progressed through the K-12 system. Since then, the standards have consistently guided instructional practices in technology education, as well as help teachers define and come up with new ways to enhance learning experiences of their students. Today, technology education students learn about the technological world that inventors, engineers, and other innovators have developed. The field strives to assist students in developing technology literacy and an understanding of what technology is, how it is created, how it shapes society and how society gives form to technology (Scott & Sarkees-Wircenski, 2004).Therefore, throughout the history of technology education the basic principle of the subject has been to provide solutions to immediate societal and economic problems (Lazerson & Grubb, 1974).

Currently, the field of technology education stands at a critical juncture in its history. Clark (1989) postulated that technology education was in a crisis, largely caused by the increasing changes that are occurring within society and technology. According to O'Riley (1996), in some places technology education has been construed as a separate subject for study and in others it is seen as an emphasis to be included in all subject areas across the curriculum. Israel (1992) posited that there was a need to develop a multifaceted curriculum that depicted the versatile nature and scope of technology education. Lewis (1999) stated that the relationship of technology education to other subjects in the curriculum was a fruitful area of inquiry. He posited that it was imperative to find out if integration with other subjects helped improve student learning of technological concepts and processes. In the same line of thought, Wicklein, Hill, and Daugherty (1996) stated that there were continued efforts to better communicate the nature of technology education content, the delivery of the content, and how technology education fits within the general education curriculum.

In order to encourage advancements in programs, one of the thrusts has been to identify exemplary practices. Zuga and Bjorkquist (1989) argued that such subjects will be those that are representative of high technology and are fixated to the modernization of modern life. These arguments place engineering as the professional field most closely associated with technology. Dugger (1993) stated that there were remarkable similarities between engineering and technology education and that both fields treated problem solving as the heart of their philosophical being. According to Dugger, engineering could be considered as a very refined area of study and professional endeavor of the broader discipline of technology education. To this end, Dearing and Daugherty (2004) pointed out there was a need to carefully craft curriculum materials and educational philosophy with the alignment of pre-engineering education with technology education emphasizing the engineering principles and the design applications of the principles. If technology education is to fulfill its most fundamental mission and substantiate its position in the society as a worthwhile subject, teaching and learning methods must adapt so that technology and its components are used to their fullest potential. Thus, infusing aspects of engineering design as a focus for the technology education curriculum would be a reasonable strategy to address these concerns.

Today, Americans find themselves living in an increasingly interconnected world in which the marketplace is global and requires competitive skills and knowledge to survive. In industry, the focus is on customer satisfaction, market share, quality, product and process improvements, value creation, productivity, just in time policies, and return on investment. According to Leask (2001) these rapid changes have illustrated the necessity for regular review of curricula and the need to constantly upgrade teachers' knowledge and skills. Teaching today presents a progressively multifaceted work environment which requires key values of professional practice to execute it well. Preparation of individuals for the technological world must impart in them skill sets like critical thinking, reasoning skills, technical skills, and the capacity to read, write and compute at increasingly complex levels to enable them meet industry competencies.

Morrow (1994) posited that engineering education has carved a niche in today's world in which engineering and technology are the engines of economic growth, the source of jobs and higher standard of living. To engineer means solving a problem that has practical consequence. Since time immemorial, engineers have been involved in many construction and idea generation projects, revolving their final products around the process of design. Thus, the story of engineering depicts increased use of and emphasis on human intellect, interaction, design and improvement of crude tools to transfer physical labor from human shoulders onto machines. Design therefore, is considered a vital part of an engineer's preparation, with engineering classes being tailored to graduate engineers who can design effective solutions to meet social needs.

Today, the rate of technological advancement is crucial to every nation's economic growth and well being. The industrial context in which products were being manufactured in yester years has changed from a sequential one to a simultaneous one requiring team work at every level of production. According to Willenbrock (1988) employment opportunities will expand for those with engineering skills as each and every sector of the economy is turning to highly trained technical literate individuals to devise new systems for conducting their business. Therefore, engineering and problem solving skills are critical and are needed throughout the society. To this end, there is a need for technology and engineering educators to continuously update their skills and knowledge and expose students to engineering design concepts.

Teacher Professional Development Practices

Teachers have been charged with the important responsibility of shaping our children's future. Throughout the history of schooling teachers have continuously sought to work with students in more appropriate and effective ways to promote learning and achievement of curriculum objectives. According to Blackman (1989) teachers are continuously in search of answers to questions concerning school purposes, and the relationship between schooling and broader educative functions of the society at large.

There are three components of a teacher education program: general education, subject matter preparation, and professional development. General education includes studies common to all college majors, that is, classes focused on humanities and liberal arts. Subject matter preparation encompasses specific training in a content area, while professional development includes preparation focusing on the pedagogy of teaching (Cruickshack, 1990).

Professional development sometimes referred to as inservice training is one way that teachers have found solutions to pertinent issues facing the profession. Billings (1977) stated that in an ideal world, professional development of teachers would be regarded as a deliberate and continuous process that involves the identification and discussion of present and anticipated needs of individual staff. This will help further teachers' job satisfaction, and career prospects as well as the goals of the school (as cited by Bell, 1991). According to Holly and Mcloughlin (1989) these new learning opportunities and information that are sought by teachers have come to be referred to as professional development activities. Thus, professional development learning activities have been described as the catalyst for transforming theoretical knowledge into practice (Kent, 2004).

Hoyle (1982) defined professional development as a process whereby a practitioner acquires and improves the knowledge and skills required for effective professional practice. In other words, professional development is a continuous process by which professionals enhance their competence, skills and knowledge in their professions. As documented on the U.S. Department of Education website (1998), 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 the new challenges of guiding all students in achieving higher standards of learning and development. The above explanations espouse the belief that professional development is closely linked with school improvement and student learning. Hence, the strengthening of professional development needs to be at the center of educational reform in the United States (Bredeson, 2003).

Hassel (1999) defined professional development as the process of improving staff skills and competencies needed to produce outstanding educational results for students. Holly (1991) noted that professional development as a continuous incremental process built on the existing skills of practitioners. Fullan and Steigelbauer (1991) stated that professional development was the sum of formal and informal learning experiences throughout one’s career from preservice teacher education to retirement. According to Thompson and Zeuli (1999) professional development is “learning by widening circles of teachers, so that it is not only these teachers’ knowledge but also the whole profession that develops" (p. 376). Over the years, professional development has been regarded as a key means through which teachers are consistently aware of current issues in education. Eventually, this has helped them put into practice new ways of teaching while refining their best practices.

The above definitions suggest professional development to be an ongoing activity that teachers and other professionals undertake to improve their knowledge and teaching skills as circumstances change, and positively impact their fields of study, practice in addition to students' learning experiences. Thus, professional development activities often bring together educators from different locations for common experiences and learning. They provide opportunities for participants to focus intensely on topics of interests for an extended period of time (Loucks-Horsley, Hewson, Love & Stiles, 1998).

According to Taylor (1975), two aspects of the professional development of teachers include staff development and further professional study. He defined further professional study as being oriented to the needs of individual teachers, while staff development was rooted in the needs of the institution (as cited by Bell, 1991). Bellanca (1995) explained that staff development is the effort to correct teaching deficiencies by providing opportunities to learn new methods of classroom management and instruction. On the other hand, she defined in service programs as the scheduling of awareness programs usually of short duration to inform teachers about new ideas in the field of education. It can then be argued that there is no distinct difference between professional development activities and inservice programs. Both activities have a common goal: to offer teachers the opportunity of life long learning as they hone their skills and knowledge.

Huberman (1995) posited that teachers have different aims and different dilemmas at various moments in their professional cycle, and their desires to reach out for more information, knowledge, expertise and technical competence will vary accordingly. Therefore, the nature of professional development undertaken may differ, depending upon where one is in his/her career or life stage: early, middle, or late (Holly & Mcloughlin 1989). Okun (1984) explained that the concept of life stage was age-related and served as a useful framework seeking to provide some understanding for a lifespan perspective that assumes changes in individuals must be considered in the context both of the prevailing norms of the day and of the historical time within which one lives. Okun based her work on the works of Carl Jung, Charlotte Buhler, and Erik Erikson twentieth century pioneers of adult development theory.

Adult development theory suggests the following career life cycles: early adulthood which encompasses ages 25-45, middle adulthood, 45-65 and late adulthood 65 and over. Thus professional development activities perpetuate the concept of lifelong learning among teachers seeking to improve their repertoire of knowledge and skills. Longworth and Davies (1996) defined lifelong learning as the development of human potential through a continuous supportive process which stimulates and empowers individuals to acquire the knowledge, values, skills and understanding they will require throughout their lifetimes and to apply them with confidence, creativity and enjoyment in all roles, circumstances, and environments. Peterson (1983, p. 5) suggested that lifelong learning is a conceptual framework for “conceiving, planning, implementing, and coordinating activities designed to facilitate learning by all Americans though out their lifetimes.” Thus, learning is a fundamental activity in any individual’s lifetime and takes various forms. However, the learning tasks undertaken need to be ongoing, interactive, and supportive to the teacher.

Sullivan and Glanz (2006) defined learning as the construction of meaning from experience. Learning is not “delivered” by one person to another. Learning is meaning construction, when facilitated by another person, whether it is a formal teacher or a peer, and is most likely to occur in a relational space. This relational space is created through shared understanding and mutual recognition. Individuals need to be fully engaged for meaning construction to occur, and full engagement requires the learner to bring all of his or her abilities and experiences to the learning process. We make meaning together when we “put our minds together” and create new understandings of the world. Therefore, learning can be seen as a process of construction that not only involves additions to knowledge but also may, on occasion, involve remodeling of existing knowledge (Loucks-Horsley, et al., 1998).

Therefore, professional development activities provide crucial learning opportunities for teachers to examine personal beliefs in the actual classroom context and to evaluate those beliefs, eventually reinforcing, adapting or rejecting them (Henry, 1999). Bellanca (1995) argued that, professional development begins with an individual’s choice to expand his or her repertoire of knowledge and skills. She further stated that for a teacher, this may be through a graduate program, a workshop, a conference, or an action research project that helps them understand and be able to engage in higher quality teaching. There are many professional development models for teachers (Lavoie & Roth, 2001; Loucks-Horsley, et al., 1998). These models guide the planning, organization, implementation, monitoring and evaluation of any teacher education or preparation program. Various frameworks of professional development models in teacher education exist, for example, the collegial support, the collaborative, staff development, and teacher as a curriculum developer professional program models.

The collegial support model. According to Rodriguez and Johnstone (1986) this approach is based on building collegial support among teachers and between teachers and administrators. This model not only corrects weakness in the present structure of professional development programs but also helps teachers reach higher levels of professionalism and self-satisfaction by encouraging them to become involved in problem solving, decision making, and goal setting for themselves, their departments and their schools.

To develop and implement collegial support model, educators should provide professional growth on two levels: process and content. Process skills include those needed to identify personal/professional and school (or department, subject area, or grade level) weaknesses and needs, and to create goals and plans to remedy those weaknesses and needs. Brainstorming, reaching consensus, problem solving, prioritizing, long range planning, team building, and collegial support are among the process skills that are modeled and practiced by participants throughout the program. The program content evolves from the personal/professional plans and school improvement plans developed by the participants. Thus, the content of this program is relevant and motivating to the participants because they themselves have chosen it (Rodriguez & Johnstone, 1986).

The collaborative model. Collaborations in professional development of teachers are partnerships that bring together local education agencies, teacher preparation institutions, funding agencies, school districts, business and industry, and informal education sites. Partnerships can work together to support education reform (Barufaldi & Reinhartz, 2001). Such partnerships may comprise instructional teams made up of professors from universities, community college instructors, state supervisors and coordinators, and master teachers from local high schools. Further, Barufaldi and Reinhartz (2001) stated that the main goal of a collaborative model was to provide public school teachers opportunities to upgrade their content and pedagogical knowledge to enable them offer their students interesting, relevant, experiential, and meaningful science learning experiences.

Dillon-Peterson (1986) stated that there were definite advantages to having two or more teachers working together on professional development activities. This strategy enabled teachers to look at teaching from a different perspective. Such collaboration builds a feeling of support, ownership, and competence as well as commitment to professional development for themselves and others. Therefore, through collaborative efforts, teachers reflect on their teaching experiences and what they learn during their professional development sessions. Lavoie (2001) postulated that reflection was a powerful tool to improve learning. Reflection typically involves questioning, analyzing, hypothesizing, and evaluating behaviors which result in practical modifications to one's teaching strategies. Osterman and Kottkamp (2004) postulated that professionals who engage in reflective practice work on issues relevant to them in settings where they work. They stated that reflective practice was about individuals working with others to critically examine their own practice to resolve important problems. Under such learning circumstances, teachers have opportunities to exchange their views with colleagues and are able to make sense of any scientific misunderstandings or misconceptions that may arise during their professional development (Barufaldi & Reinhartz, 2001).

Teacher as a curriculum developer professional program model. This model enables teachers to actively carry out education reforms by participation in curriculum materials development and implementation of new course materials. Loucks-Horsley, et al. (1998) stated that curriculum materials developed under such a model are appreciated by many teachers and easily implemented in comparison to materials developed individually. Under this model, teachers are provided opportunities to share their insights on content and process of teaching the curriculum materials they pilot in their own classrooms during professional development activities (Loucks-Horsley, et al., 1998). According to Loucks-Horsley, et al., (1998) this model provides teachers with opportunities to interact with their peers as they develop innovative activities and teaching approaches for new courses and curriculum materials. This model elicits the aspect of communities of practice in professional development. It portrays teachers as a group of people, with common interests, interacting and sharing ideas that promote teaching and learning activities in schools.

Role of Theory in Teacher Professional Practice

Theory Defined

Kerlinger, (1986) and Babbie, (1992) defined theory as a set of interrelated concepts, definition, and propositions that present a systematic view of events or situations by specifying relations among variables in order to explain situations. According to Glanz, Rimer, and Lewis (2002) theories are abstract by their nature, hence they do not represent any topic or specialization. Torraco (1997) suggested that theory explained what a phenomenon was, and how it worked. Therefore, theories exist to explain and predict events and behaviors that have been consistent over some given time period.

Theory establishes the framework of the field and helps persons within the field examine and synthesize data, organize concepts and principles, suggest new ideas and relations, and even speculate about the future statement or set of statements used to explain a phenomena. Ornstein and Hunkins (2004) stated that a field of study basically involves theoretical and practical knowledge. In other words theory informs practice and forms a basis from which individuals in a field of study can base their actions or infer their beliefs. Glanz, Rimer, and Lewis (2002) shared similar thoughts, they postulated that theories and models explain behavior and suggest ways to achieve behavior change. For example, explanatory theories sometimes referred to as a theory of the problem; guide the search for modifiable factors such as knowledge, attitudes, self efficacy and social support. These theories help describe and identify why a problem exists. It would then follow that a theory is generally accepted as valid due to having survived repeated testing and its ability to explain actions and behaviors in certain given situations. For example, John Watson (1913), Edward Thorndike (1911), B.F. Skinner (1954), and Ivan Pavlov (1895) performed experiments that helped shape behaviorism as a theory. Through their ideas and experiments behaviorism has been defined as a theory that suggests learning occurs when an environmental stimulus triggers a response or behavior.

So what is a learning theory? A learning theory is a systematic, integrated outlook on the nature of the process whereby people relate to their environment and how they learn (Schunk 2004). It is a systematic approach to the understanding of human behavior that emphasizes the way in which learning comes about and takes place. Gredler (1997) posited that learning theories provide a mechanism for understanding the implications of events related to learning in both formal and informal settings. Learning theories including those by Jean Piaget (cognitive structures), William Perry (cognitive, intellectual development and positionality) and David Kolb (experiential learning) should apply to education and human development in design theory and sciences illuminating meaningful associations among each other (Eder, 1994). Gredler (1997) cautioned that no one particular theory can possibly address all the complexities found in various settings and contexts in which learning can occur. Therefore, a particular theory should be chosen for a situation in part as a result of the activities to be studied. According to Schunk (2004) the learning theory used depends upon the learning situation and differ in how they address critical issues. Critical issues include thinking about how learning occurs, factors influencing learning, role of memory, role of motivation, transfer of learning, processes involved in self-regulation and the implications for instruction.

Thus, theories attempt to explain various types of learning but differ in their ability to do so. Theories differ on how they address critical issues. Although there are many different learning theories that have been proposed, Rogers (2002) suggested three main groups: behaviorist theories, cognitive theories and humanist theories:

Behaviorist theories: These are theories that emphasize the forming of associations between stimuli and responses through reinforcement or extinction of desired behavior. This theory applies to educational practices that reward performance behaviors to encourage repetition of those behaviors or punish to discourage further occurrences of undesired behavior.

Cognitive and constructivism learning theories: Cognitive learning theories refer to the preferred way individual's process information. These theories point to the active engagement of the mind in learning, stressing the process involved in creating responses, organization of perceptions and the development of insights. On the other hand, constructivism is not a theory but an epistemology that explains the nature of learning (Schunk 2004). It contends that individuals construct what they learn and understand.

Humanist theories: These theories spring from an understanding of the major contemporary changes in culture. Learning and setting goals for one-self are intrinsic and develop largely from one's past experiences. Thus learning emanates from the potential of human growth. The learner's actions create the learning environment and situation.

So how do people learn? According to Kolb (1984), learning is a process whereby knowledge is created through the transformation of experience. In other words, learning is adjustment, or adaptation to a situation. In the same vein, Knowles, Holton, and Swanson (1998) defined learning as a process by which behavior is changed, shaped or controlled. Schunk (2004, p. 2) offers a more comprehensive definition. He stated that “learning is an enduring change in behavior, or in capacity to behave in a given fashion, which results from practice or other forms of experience.”

People perceive and process information differently. Each individual is unique and has a learning style to which they ascribe when processing information. A learning style can be described as a person’s characteristic strengths and preferences in the ways they take in and process information. Hitch and Youatt (1995) defined learning styles as the composite of characteristic cognitive, affective and physiological factors that serve as relatively stable indicators of how learners perceive, interact with and respond to the learning environment. According to Felder (1996), these characteristics vary from person to person, and may be strong, moderate, or almost nonexistent, may change with time, and may vary from one subject or learning environment to another. In light of these observations, it can be argued that learning styles describe an individual’s way of thinking, remembering or problem solving strategies, in addition to playing a significant role in the ways people acquire and process new information in different contexts.

Perkins and Salomon (1992) stated that when knowledge acquired in one context enhances or undermines a related performance in another context, then transfer of learning has occurred. In other words, the ability to apply knowledge or procedures learned in one context to solve problems in a new or similar context is referred to as transfer. Detterman (1993) defined transfer as the degree to which a behavior will be repeated in a new situation. In the same vein, Mestre (2002) described transfer, as the ability to use what was learned in one setting in a different one, as well as the ability to solve novel problems that shared a common structure with the knowledge acquired through learning. Perkins and Salomon (1992) posited that learning new concepts depended on transfer. If transfer does not occur as frequently as educators would like, then this posed a key problem in education. A combination of flexible learning styles and understanding of efficient learning strategies that can enable the transfer of learned concepts to similar contexts will produce learning experiences that suits individual styles and maximizes the learners' potential (Lockitt, 1997).

Therefore, having an understanding of learning styles is important because learning styles are key expressions of the uniqueness of an individual and the way he/she processes information. According to Hitch and Youatt (1995) learning styles describe the physical, social, environmental, and sociological elements that help an individual learn effectively. Kolb (1984) pointed out and described four types of learners as illustrated in figure.

Figure 1. Learning styles as described by Kolb

Learning Style	Learning characteristic	Description
Convergent	• Abstract conceptualization • Active experimentation	Strong in practical application of ideas, problem solving, decision making.
Divergent	• Concrete experience • Reflective observation and thinking	Opposite of convergent. Strong in imaginative ability good at generating ideas and seeing thing from different perspectives.
Assimilator	• Abstract conceptualization • Reflective observation	Strong ability to create theoretical models and excels in inductive reasoning. Concerned with abstract concepts rather than people.
Accommodator	• Concrete experience active experimentation	Greatest strength is doing things. More of a risk taker and opportunity seeker. Performs well when required to react to immediate circumstances. Solves problems intuitively.

Note. From: "'David A. Kolb on Experiential Learning.' *The Encyclopedia of informal Education*," by Smith, M. K. (2001). Retrieved October 12, 2005, from www.infed.org.

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Theoretical Perspectives

According to Bruner (1990) an individual's way of life revolved upon shared meanings and ideas as well as shared modes of discourse for negotiating differences in meaning and interpretation. Thus, previous experiences and situations affect the way individuals perceive respond and construct meaning from new information. This allows individuals to understand the world in which they operate. Past experiences, coupled with years of teaching and age, have helped prepare people for the way they make meaning from situations they find themselves. Experiences have then helped mold the self, which struggles in a constant effort to understand the changing world.

Jewell-Lapan (1936) stated that, what individuals perceive is always present in time, and what individuals know may have existed in the past, or may exist in the future or may be a universal correlation. Merriam and Caffarella (1991) referred to this process as cognition. They stated that cognition described how people receive, store, retrieve, transform and transmit information. In other words, people use their cognitive abilities to construct perceptions from previous and present experiences, in addition to situations and surroundings that they may find themselves in. Weil (2004) stated that cognition allows individuals to see thoughts underlying their feelings. It helps individuals provide meaning and organize experiences encountered, allowing them to reflect and go beyond given information and adapt to situations. In other words, learning involves the active engagement of the mind in creating responses, organization of perceptions and the development of insights into situations.

Schunk (2004) pointed out that, learning is therefore optimized when the student is aware of the process that he or she is structuring, inventing and employing. Weil (2004) referred to this as metacognition, a process that meshes our past, present and future into a journey of self analysis and requires us to examine our thoughts and feelings critically. Griffith and Ruan (2005) defined metacognition as awareness and judgement about an event gained through experience. In the same vein, Fogarty (1994) described metacognition as knowing what you know and don't know. It is self-awareness of one's thinking and learning. In other words, metacognition is a thinking process that calls for in-depth thinking by which an individual comes to understand and make connections between their past and present experiences. Bruner (1990) observed that constructivist theory was a general framework of instruction based upon the study of cognition.

Constructivism

Bruner (1990) posited that individuals' way of life revolved upon shared meanings and ideas as well as shared modes of discourse for negotiating differences in meaning and interpretation. Schwandt (1998) stated that individuals do not construct our interpretations in isolation but through social interaction involving history, language and action. Pepin (1998) stated that human beings survive and adapt to their existence by providing forms to the flow of experience which they are capable of manipulating. In this view, Pepin argued that the world has no pre-established form and did not admit of direct perception or knowledge; however it assumed a form that was suitable to us, when constructed by the eye.

According to Von Glaserfeld (1995) knowledge should be thought as a collection of ideas and actions that one has found to be successful, given the purposes that one has in mind. Jarvis (1992) pointed out that every experience about which individuals internalize is perceived through all the learning embedded in their funds of knowledge as a result of previous experiences. Pepin (1998) posited that new knowledge cannot develop in a void but requires the alteration of previously existing constructions, thus for experiences to be perceived they must have undergone construction previously. Thus, it can be argued that no experience is free of previous ones, and this affects the way we perceive and respond to situations. Fosnot (1996) referred to this process as constructivism and it described both what knowing was and how one came to know.

Constructivism is the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context. Meaning is not discovered, but rather constructed (Crotty, 1998). Pepin (1998) argued that constructivism is concerned with practical and experiential types of knowledge and provided a theory offering a global perspective on how human beings impart meaning to their existence in order to survive and adapt. Doolittle and Camp (1999) explained that constructivism acknowledges the learner's active role in the personal creation of knowledge, the importance of experience in this knowledge creation process and the realization that the knowledge created will vary in its degree of validity as an accurate representation of reality.

Von Glaserfeld (1998) proposed three essential epistemological beliefs of constructivism, including (a) knowledge is not passively accumulated, but a result of active cognitive processes by an individual, (b) cognition is an adaptive process functioning to make an individual's behavior more viable given a particular environment, and (c) cognition organizes and makes sense of one's experience and is not a process to render an accurate presentation of reality. To this end, it can be argued that constructivism provides a framework for meaning making and it can be assumed that people construct their own knowledge and an understanding of the world from their experiences and interactions with others.

Knowles, et al. (1998) argued that constructivism stressed that all knowledge is context based and that individuals make personal meaning of their learning experiences. They pointed out that learning is contextual, situational and cumulative in nature, thus new information must be related to previous experiences for learners to retain and use it. Schunk (2004) explained that constructivism is not a theory but an epistemology that explains the nature of learning and how individuals construct what they learn and understand. Thus, a number of educators have come to regard constructivism as a learning theory. As a theory, constructivism defines knowledge as temporary, developmental, socially and culturally mediated and non-objective. Pepin (1998) explained that through learning individuals constantly attempt to create the world in their image and containing it within structures available to them and is part of their make up. The learning taking place enabling persons to achieve this enjoys such status that people end up believing the world is indeed as they perceive and construct it. Therefore, learning, from a constructivism perspective is understood as a self-regulated process of resolving inner cognitive conflicts that often become apparent through concrete experience, collaborative discourse and reflection (Brooks & Brooks, 1999).

Briner's (1999) posited that "learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure" (p. 1, as cited by Kizito, 2001). This implies that learning is a series of interrelated events, and takes place when tasks are encountered, performed and are immediately or later reflected on, constructed and applied in real-world situations. This means that all knowledge which persists and is perpetuated is knowledge which, until that time, has proven viable and adaptable for the person who has developed it (Pepin, 1998).

People perceive and process information differently. Each individual is unique and has a learning style to which they prescribe when processing information. A learning style can be described as a person's characteristic strengths and preferences in the ways he/she takes in and processes information. Hitch and Youatt (1995) defined learning styles as the composite of characteristic cognitive, affective and physiological factors that serve as relatively stable indicators of how learners perceive, interact with and respond to the learning environment. According to Felder and Brent (2005) these characteristics vary from person to person, and may be strong, moderate, or almost nonexistent, may change with time, and may vary from one subject or learning environment to another. Thus, learning styles is a particular way in which an individual learns and it describes a person's typical style of thinking, remembering or problem solving. Learning styles are important because they express the uniqueness of an individual and specifically deal with the way the individual processes information. Pepin (1998) argued that there would be no learning taking place if no prior construction of experiences existed. According to Von Glaserfled (1998), learning new concepts and the way they may be constructed would depend on what has already been learned.

Bruner (1990) stated that constructivist theory can be viewed as a general framework of instruction based on the study of cognition. Cognitive processes involve the active engagement of the mind in learning, stressing the process involved in creating responses, organization of perceptions and the development of insights (Schunk, 2004). In other words, it is a process of thinking, questioning, analyzing and problem solving. Based on constructivist epistemology and its role as a theory of learning, Pepin (1998) suggested that it was possible to construct and foresee future experience only on the basis of our current construction of past experiences. Therefore, it can be argued that knowledge is constructed, and teachers' perceptions in this study will be the opinions of knowledge and beliefs about daily events that they encounter as they make sense out of new information and experiences through meaningful interaction of new ideas with what they already know and believe as they participate in engineering design professional development activities.

Communities of Practice

Jean Lave and Etienne Wenger coined the term *communities of practice* to describe what they researched in studying apprenticeship as a learning model (Lave & Wenger, 1991; Wenger, 2004). Communities of practice represent a theory of learning that assumes engagement in social practice is the fundamental process by which individuals learn and so become who they are. The primary unit of analysis is neither the individual nor social institutions but rather the informal “communities of practice” that people form as they pursue shared enterprises over time. This perspective explores in a systematic way the intersection of issues of community, social practice, meaning, and identity (Wenger, 1998).

According Wenger (1998), a community of practice can be definedf along three dimensions:

What is it about? Is it a joint enterprise as understood and continually renegotiated by its members?

How does it function? Is there some form of mutual engagement that binds members together into a social entity.

What capability has it produced? What are some of the shared responsibilities and communal resources and that members have developed over time.

Wenger (2004) stated that communities of practice are groups of people sharing a concern or a passion for something they are doing, and learning how to do it better as they interact regularly. He further argued that not everything called a community is a community of practice. For example, a people living in the same neighborhood often form a community, but it is usually not a community of practice. According to Wenger (1998) for a community of practice to function, it needs to develop and apposite shared ideas, commitments and memories among its members. It also needs to build into it resources such as tools, documents, routines, and an understanding among its members in order to disseminate knowledge and information amongst members. Wenger (2004) postulated that for community of practice to grow and exist, three characteristics are crucial: a domain, a community, and a practice.

The domain. According to Wenger, a community of practice has an identity defined by a shared domain of interest. To belong to such a group, an individual should show commitment to the domain, and therefore a shared competence that distinguishes members from other people.

The community. Wenger posited that members of a given domain engage in joint activities and discussions, help each other, and share information in pursuing their interests as they build relationships enabling them to learn from each other. Wenger argued that a website in itself is not a community of practice neither does having the same job or the same title makes for a community of practice unless members interact and learn together.

The practice. Members of a community of practice are practitioners. They develop a shared repertoire of resources, that is, experiences, stories, tools, and ways of addressing recurring problems.

Professional Development from Constructivism and Communities of Practice Perspective

Professional development activities play a vital role in the professional lives of teachers, offering them an opportunity to reflect on education reforms in relation to curriculum trends, and changes in their beliefs of subject matter and practice. The social context of teacher preparation activities and learning influence the ways preservice and inservice teachers construct new knowledge. Teachers' interaction and participation in their communities' cultural and professional activities facilitate acquisition of new knowledge through practical experiences. Constructivist and communities of practice theories recognize individuals as active agents in the construction of their knowledge. Social constructivism takes into account one's contribution to meaning and learning through individual and social activity (Lavoie & Roth, 2001).

Atwater (1996) posited that an individual or society's knowledge is not static. Through interaction, human beings share knowledge with other people within his/her immediate community and wider society. However, he cautioned that due to different life experiences, each person's knowledge base may be different from another person’s. People sharing similar professional and cultural values and experiences are likely to perceive a given phenomenon in a given setting differently depending on their prior experiences and ways of thinking. In view of this assumption, individuals hold different perspectives to phenomenon and continuously construct knowledge and new meanings as they make sense of their immediate environments.

According to Calderhead and Shorrock (1997), research in teacher education cannot, at present, offer one comprehensive theory of professional development. Very many variables clearly influence the growth of teachers’ practice and it is difficult to order and categorize these in a way that provides meaningful and coherent account of teacher development practices. Thus, the review of literature in this study guided the researcher to reflect on existing professional development models, study participants’ thought processes and reactions toward professional development, as well as conceptual frameworks guiding the study.

Summary

To conduct a study of this nature it was necessary to explore literature from which to base my study. Today and in the foreseeable future, technology education as a field faces a very dynamic environment with calls for new curricula, changes in the way students are prepared for the changing work environment in addition to an acute shortage of teachers who are adequately trained to keep up with the technological wave. To meet these challenges, experts in the field have proposed infusion of engineering design aspects into technology education. This chapter therefore, presented literature that highlights history and evolution of technology education to its present state, the role of theory in teacher professional and development practices, and theoretical frameworks that guided analysis of data.

CHAPTER 3

METHOD

Introduction

This chapter describes the research methodology that was used to describe a process of preparing technology education teachers to teach engineering design concepts in the context of technology education. This process will be identified through professional development activities that secondary technology teachers undertake at two selected National Center for Engineering and Technology Education (NCETE) sites. In order to identify this process, I chose to use a qualitative approach methodology. In qualitative research, reality is constructed by individuals as they interact within a social context (Merriam, 1998). A social constructivist theoretical framework guided this multisite case study of two NCETE sites involved in teacher professional development activities. This chapter includes a description of the (a) purpose of this study, (b) the design of this study and the nature of qualitative research, (c) research setting and participant selection, (d) data collection procedures, (e) data analysis procedures, (f) validity and reliability, and (g) researcher subjectivity statement.

Purpose of Study

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 using a case study design. This process was identified through a study of professional development activities that are 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. Specific objectives of the study were to (a) investigate the content, methodology and instructional practices of teacher educators facilitating engineering design workshops at two selected NCETE sites, and (b) document secondary technology teachers' reflections concerning their experiences with respect to content, delivery methods, strengths, and weaknesses of engineering design professional development activities at two NCETE sites.

Research Questions

This study was guided by the following research questions:

1. How are the two sites similar or different?
2. What factors influence teacher educators' choice of content and instructional activities when conducting engineering design professional development workshops?
3. What theories of instruction and learning do teacher educators use to teach engineering design in professional development workshops? What influences teacher educators' choice of theories?
4. How do teacher educators conducting professional development workshops evaluate the effectiveness of the workshops in meeting stated objectives?
5. What are the reflections of secondary technology teachers' experiences with respect to content, delivery methods, strengths, and weaknesses of the engineering design workshops? What do secondary technology teachers say are the strengths and limitations of each program?
6. What would secondary technology teachers like to have changed in engineering design professional development workshops with regard to content and instructional activities? What are the reasons for the changes?

7. What implications for subsequent programs can be drawn from data collected at the two sites?

The Design of the Study and Nature of Qualitative Research

To describe a process for preparing technology education teachers to teach engineering design concepts in the context of technology education, 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.

The study sought to investigate the content and instructional practices of teacher educators administering engineering design workshops at selected NCETE sites as well as secondary technology teachers' reflections on their experiences with respect to content, delivery methods, strengths, and weaknesses of the workshops. A qualitative 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.

Qualitative research assumes that reality is constructed by individuals in interaction with their social worlds. Merriam and Simpson (1995) posited that a qualitative approach enables a researcher to study how people make sense of and interpret their lives. This approach helped yield knowledge about opinions, attitudes and practices of participants through their responses. According to Charmaz (2002), qualitative research involves gathering of extensive amounts of rich data with thick description. Patton (2002) pointed that thick descriptions provide a detailed account of the phenomenon under study forming the foundation for qualitative analysis and reporting.

It was anticipated that through collection of rich descriptive data, that I will outline faculty best practices when developing, implementing, and conducting professional development activities and participating teachers' experiences towards these activities. To gather rich descriptive data, one technique that qualitative researchers utilize is fieldwork. In fieldwork the researcher physically goes to the setting for data collection. Gall, Gall, and Borg, (2003) stated that fieldwork involves the study of phenomenon in its natural setting. In this study, I visited, observed, interviewed, and took video footage of workshop participants at two NCETE sites conducting professional development activities over the summer of 2006. These sites were of interest because they administered professional development activities geared toward infusing engineering design concepts into technology education curriculum to middle and high school technology education teachers.

The study was concerned with describing faculty best practices and experiences of secondary technology teachers within two purposefully selected bounded sites. Such a phenomenon is best described as a multisite case study (Yin, 1994). Merriam (1998) defined a case study as an intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process, or a social unit.

According to Bromley (1986) case studies get as close to the subject of interest as they possibly can by means of direct observation in natural settings and their access to subjective factors such as thoughts, feelings, and desire. In the same vein, Merriam (1998) stated that researchers use case study design in order to gain in-depth understanding of a phenomenon of interest and its meaning for those involved. The researcher therefore immerses him/her self in the phenomenon being studied to investigate themes or variables that may surface during the study of the selected case. The emergent themes are sorted and grouped until common patterns emerge that define the phenomenon of interest. According to Devaus (2001) a case is the object of study; it is the unit of analysis about which we collect information. Therefore, in case study design, it is this unit that we seek to understand as a whole. Devaus further stated that the unit of analysis may be a person about whom one tries to build up an understanding that is informed by the context in which the whole case exists. To this end, qualitative case study is a suitable methodology for dealing with critical problems of practices and extending the knowledge base of various aspects of education (Merriam, 1998).

In this study 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, I 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. According to Stake (1994) case study researchers seek to see what is natural in happenings, in settings, in expression of value. What they are unable to see for themselves is obtained by interviewing people who did see or by finding documents recording the topic of interest.

To this end, constructivism and communities of practice frameworks were chosen to guide the researcher to interpret participant’s perceptions. Constructivism emphasizes diversity and recognizes that learners can make connections with knowledge in many different ways. This framework suggests a strong connection between design and learning. Constructivism asserts that activities involving making, building, or programming provide a rich context for learning (Kafai & Resnick, 1996). Moshman (1982) outlined and distinguished three interpretations of constructivism; endogenous, exogenous and dialectical. According to Moshman, endogenous constructivism, knowledge construction is individual and is fundamentally a reconstruction of structures preformed in external reality. Exogenous constructivism is more of development than learning, and involves internal construction of new knowledge from old. Dialectical constructivism states that the source of all knowledge lies in the continuing interactions between organism and environment, neither of which can simply impose itself on the other.

Evard (1996) posited that constructivism is based on the idea that people learn well when making things that can be shared with others. In other words, the nature of the topic, as well as the environment, and community of the participants, impact learning. In view of these observation communities of practice and social constructivism were chosen as frameworks to guide this study.

Time Schedule

Table 1 summarizes the procedures and corresponding time periods that informed the design of the study.

Table 1. **Overview of dissertation study work plan**

Time Period	Procedure
June – July 06	Communication with professors offering engineering design workshops at selected study sites
	Submission of Human Subjects approval form to the University of Georgia

Table 1 (continued). **Overview of dissertation study work plan**

Time Period	Procedure
	Institutional Review Board (IRB), seeking permission to conduct dissertation study
	Follow up with identified professor at selected study sites and confirmation of dates to administer instruments to sample population
	Visit Study sites for data collection
	Conduct interviews after confirmation of dates at study site
Aug 06- Sep 06	Visit study sites for data collection, consult with major professor
	Conduct interviews after confirmation of dates at study site
Oct 06- Nov 06	Transcription of interview sessions
	Sorting and grouping of data into categories for analysis purposes
	Conduct member checks
	Begin data interpretation.
	Consult with major professor
	Writing of dissertation draft
Dec 06- Feb 07	Data interpretation and writing of dissertation
	Consult with major professor
	Plan for dissertation defense

Research Setting and Participant Selection

Research Setting

A multisite case study involves collecting and analyzing data from more than one site (Yin 1994). Herriott and Firestone (1983) stated that evidence from multisite qualitative case studies is often regarded as being more robust because the same research question is addressed in a number of settings using similar data collection and analysis procedures in each setting. Miles and Huberman (1984) posited that by comparing sites or cases, one could establish the range of generality of a finding or explanation and at the same time; pin down the conditions under which that finding occurred. In this multisite case study, 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: Eleven University and Twelve University.

Permission to conduct the study was sought through submission of a human subjects approval form to the University of Georgia Institutional Review Board (IRB), Twelve University, Office of Research and Sponsored Programs, and Eleven University, Office of Human Research Protections seeking approval to conduct the study. On approval from the IRB, a letter (appendix B), and email messages were sent to professors facilitating engineering design workshops at selected sites. The letter and email messages informed them of the research study, my travel plans to workshop sites, requested their permission to interview workshop participants and the most convenient dates and times to do so. According to Barab and Duffy (1998), situated perspectives suggest a reformation of learning in which practices is not conceived of as independent of learning and in which meaning is not conceived of as separate from the practices and contexts in which it was negotiated. In other words, instruction should be planned to be situated in context that will promote meaning making. In this study, workshop sites were designed to facilitate the learning of engineering design concepts. Figures two and three are graphical representations of the layout of laboratories used to conduct engineering design workshop at both centers.

Figure 2. Workshop laboratory layout at Eleven University.

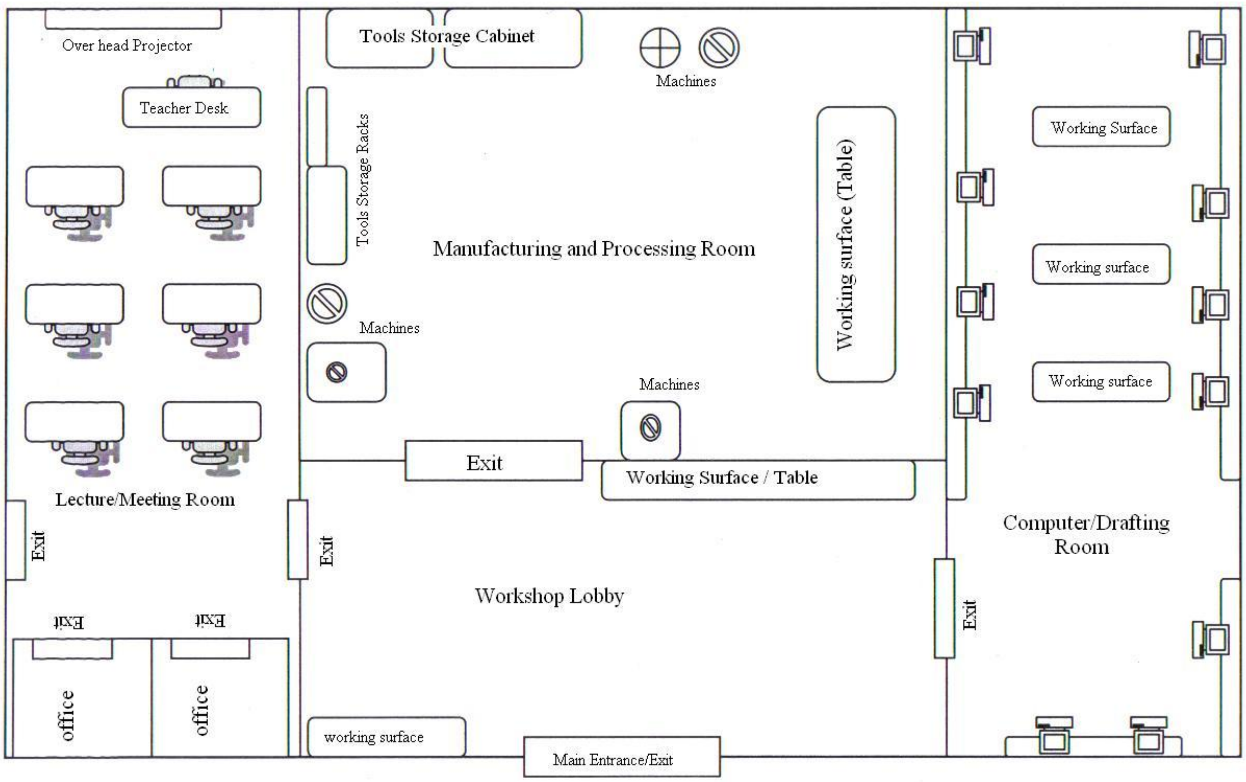
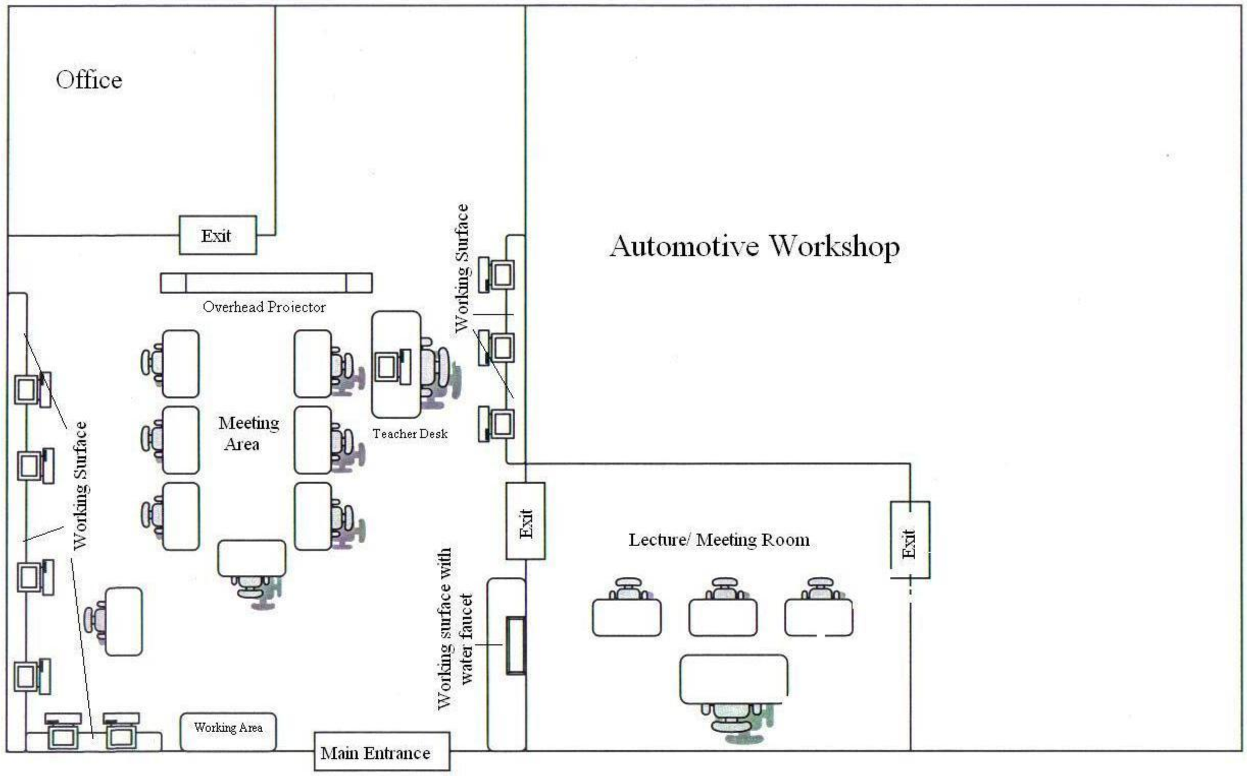


Figure 3. Workshop laboratory layout at Twelve University.



Participant Selection

There are two basic types of sampling: probability and non probability. 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. Gall et al. (2003) and Patton (2002) stated that convenience sampling is used to select a sample that suits the purpose of the study and is accessible. 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.

Patton (2002) posited that there were no rules for sample sizes in qualitative inquiry. He stated that sample size depended on what the researcher wanted to know, the purpose of the inquiry, what will be useful, what will have credibility, and what can be done with available time and resources. Merriam (1998) stated that the number of participants required in a qualitative study was not set and the ideal size was when redundancy or replication was obtained. For this study a total of 15 interviews were conducted. This number of participants was sufficient since this inquiry was qualitative in nature, and in-depth interviewing necessarily limited the number of participants for practical reasons (Patton, 2002). Participants selected and interviewed for this study included (a) Five high school and middle school teachers who taught mathematics, science, and technology education, and two professors facilitating the workshop at Twelve University, and (b) Six high school and middle school teachers who taught technology education, and two professors facilitating the workshop at Eleven University.

Data Collection Procedures

Yin (1994) stated that the case study is unique strength is its ability to deal with a full variety of data collection methods through interviews, documents, artifacts, and observations. For this study, data was collected through interviews, observations, documentation/artifacts and video footage. Maykut and Morehouse (1994) stated, that these methods are used to collect data that relate to the phenomenon of interest and what becomes important to analyze emerges from the data through a process of inductive reasoning. Interviews are among the most widely used methods of data generation. According to Patton (2002), interviewing allows the researcher to enter into the other person's perspective with the assumption it is meaningful, knowable and able to be made explicit. Semi-structured interview guides (appendix A) were constructed to aid in data collection. Berg (2001) postulated that semi-structured interview guides allowed the interviewer to probe far beyond answers that might be generated by pre-prepared standardized questions. In the same vein, Patton (2002) posited that open-ended interview questions enabled researchers to understand and capture participant's views.

I conducted interviews with each participant individually at the workshops. Each interview session lasted 30-40 minutes. After a brief introduction and explanation of the objectives of this study, participants were given the semi-structured questionnaire and asked to read and sign an informed consent form (appendix C) in English regarding their participation in the study. I gave each participant a copy of the consent form for their records and I kept one. I then engaged the participants in a discussion about their experiences in the professional development activities. The semi-structred interview questionnaire was used as a guide to elicit open-ended questions and answers during my conversation with study participants. This strategy allowed me to probe far beyond the structured questions I had prepared. I digitally tape-recorded the interviews for ease of data analysis and meaning-making of participants perspectives of engineering design workshop.

Observations and Video Footage

To observe, capture, and record day-to-day events, behaviors, and informal conversations among study participants at the workshops in this study, I wrote field notes and shot video footage of the participants completing assigned design challenges. Additional artifacts, such as workshop schedules, handouts, design challenges brief, photographs of workshop settings were also collected.

Data Analysis

Yin (1994) posited that a qualitative case study sought to build abstractions across cases. The researcher attempted to build a general explanation that fit each of the individual cases even though the cases varied in their details. Since individuals construct meaning differently, data collected for this study was analyzed using grounded theory strategies of cross-case and comparative analysis. According to Charmaz (2000) grounded theory methods consist of guidelines that aid the researcher to (a) study social and social psychological processes, (b) direct data collection, (c) manage data analysis, and (d) develop an abstract theoretical framework that explains the studied process. Charmaz (2002) further stated that grounded theory methods consisted of systematic inductive guidelines for collecting and analyzing data to build middle range theoretical frameworks that explain collected data.

According to Patton (2002) cross-case analysis and comparative analysis, are conducted when variations in the perceptions of individuals are the primary focus of the study. Since individuals construct meaning differently, data collected was analyzed using cross-case and comparative analysis. Merriam (1998) stated that each case in a cross-case analysis is first treated as a comprehensive case in and of itself. Glaser and Strauss (1967) stated that comparing as many differences and similarities in data as possible tends to force the analyst to generate categories, their properties and their interrelations as he or she tries to understand his/her data.

Ritchie (2003) posited that conducting data comparisons is an important feature of any research design. First, comparison aids in identifying the absence or presence of particular phenomena in the accounts of different groups. Second, exploring how the manifestations of phenomena vary between groups. Third, exploring how the reasons for, or explanation of, phenomena, or their different impacts and consequences vary between groups. Fourth, exploring the interaction between phenomena in different settings, lastly exploring more broadly differences in the contexts in which phenomena arise or the research issue is experienced.

Ritchie (2003) further stated that comparisons may be drawn between individuals around which the sample design was structured, or may be between groups which emerge inductively from the analytical process. According to Merriam (1998), inductive means that generalization, concepts or hypotheses emerge from examination of data grounded in the context itself. Hatch (2002) posited that inductive analysis is a search for patterns of meaning in data so that general statements about phenomena under investigations can be made. LeCompte and Preissle (1993) and Patton (2002) stated that inductive analysis is commonly used in qualitative research to discover important patterns, themes, and categories in one's data and to ultimately develop theories from data.

Inductive research begins with examination of a phenomenon and then from successive examinations of similar and dissimilar phenomena, proceeding from the specific to the general. According to Strauss and Corbin (1990), to uncover, name, and develop concepts we must open up the text and expose the thoughts, ideas, and meanings contained therein. Charmaz (2002) explained that grounded theorists code their data as they collect it. Coding helps researchers to define and categorize data, in addition to building ideas inductively. Charmaz (2000) posited that researchers are deterred by line-by-line coding from imposing extant theories or their own beliefs on the data. She further explained that line by line coding kept researchers thinking about what meanings they make of data as they asked themselves questions about it. In other words, Charmaz argued that, this form of coding helps researchers remain attuned to their subjects' views of their realities, rather than assume that they share the same views and worlds.

To begin analyzing and making meaning of this data I bracketed participants responses by becoming aware of prejudices, viewpoints, and assumptions regarding professional development activities and teacher preparation. This helped me conduct the analysis from a fresh and open viewpoint without prejudgment or imposing meaning too soon. In other words, I placed participants' stories in the foreground and moved my theoretical frameworks and biases to the background. Taking this position informed my 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. Next, I reflected on the purpose of the study and the guiding research questions as I marked phrases and words that revealed each participant's perceptions of the engineering design workshop, suggestions and concerns. As I read the interview transcripts several times, they jotted these words, ideas, thoughts, and phrases in the margins of each transcript.

I read and reread each and every line of the interview transcripts, collected documentation and artifacts, and fieldwork notes looking for codes and concepts to immerse myself into the data, exploring for themes, regularities. I also spent several hours watching and replaying the video footage looking for data and instances that supported my emerging themes. This process helped me to identify expressions relevant to participants' experiences regarding professional development engineering activities, suggestions, and concerns as I tried to make meaning of the data. Additionally, I noted discrepancies in the data and followed up with specific participants via email as I sought to clarify what they had reported. We gradually became partners in exploring their meaning-making of their experiences of at the workshop as I shared their interview transcripts. This step further opened up the data at each site for comparative analysis.

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.

Glaser and Strauss (1967) argued that understanding unique cases can be deepened by comparative analysis. Constant comparative analysis is a central analytical approach in grounded theory, which entails (a) comparing different peoples' views and experiences, (b) comparing data from the same individuals at different points in time (c) comparing incident with incident, (d) comparing data with category, and (e) comparing a category with other categories, Using theses guidelines data was broken into discrete parts, closely examined and compared for similarities and differences.

In this study, I grouped data which I found to be related in meaning into categories, events and interactions. To develop the categories, a coding system was devised. Bogdan and Biklen (2003) explained that in developing a coding system, one had to read and reread through their data, searching for data regularities, patterns as well as topics that ones data covered, certain words, phrases, patterns of behavior, and subjects' ways of thinking and repeated events that stood out. Bogdan and Biklen further suggested that respondent's words and phrases were coding categories, they were a means of sorting the descriptive data that one had collected, so that the material bearing on a given topic can be physically separated from other data.

In the same vein, Strauss and Corbin (1990) postulated that data are broken into discrete incidents, ideas, and acts that are given a name by the analyst because of the meaning they evoke when examined comparatively and in context. Alternatively, these names may be taken from the words of respondents themselves. Strauss and Corbin referred to these regularities, patterns and themes as *in vivo* codes, which they explained to be an important source of category names. Therefore, I read and reread the interview transcripts conducting line by line coding procedures, as I looked for regularities and patterns to develop initial categories. Rereading data for each participant across the months resulted in successively evolving interpretations and further development of patterns.

To develop a list of coding categories, in vivo codes were keyed into a word processor, color coding and a numbering scheme was devised to group similar concepts together. Generated in vivo codes were compared among cases and a more concise list was generated incorporating and classifying all identified codes. Strauss and Corbin (1990) argued that it was important to understand that classified objects, events and actions have attributes and that how an individual defined and interpreted these attributes determined the various ways in which concepts are classified. Since categories represented phenomena, they may be named differently depending on the perspective of the researcher, focus of the research and the research context. To dig deeper into the data, I reviewed the identified initial codes and reread interview transcripts once more to conduct focused coding. As suggested by Charmaz (2002) I adopted frequently reappearing codes to further generate codes which were abstract, general and simultaneously and analytically more incisive than many of the initial codes that they subsumed. Two research partners joined me to reread, analyze, and discuss themes as they emerged. To work at a steady pace and become more organized, I converted the entire interview transcripts into a Microsoft word table (see figure 4 below with sample data) as suggested by Ruona (2005).

The table was designed to have columns and rows containing data, initial notes, my reflection and codes. This process helped me embark on writing memos to further break the data and understand what is going within it. Strauss and Corbin (1990) defined memos as the researcher's record of analysis, thoughts, interpretations, questions, and directions for further data collection. Charmaz (2002) explained that memos can range from free writes about the codes to tightly reasoned analytic statements. Through memo writing qualitative researchers elaborate, process assumptions, thoughts, and actions that are included in their codes.

Figure 4. Data organization table.

Code	ID	Q#	Line	Data	Notes	Memos
1000	001	Q2	19-20	**P**: Hmm in your own words how would you define professional development?		
			21-35	**CR**: Uhhmm, Professional development is basically giving that student population whether its teachers or whoever helping them recognize and enhancing their skills, finding a new way to do something to hopefully be more effective in the classroom with students its really what's its kinda about, you really trying to do something so that students have better test scores, grabs the concepts better, or giving you a new set of tools to deal with diverse learners. The more we learn about the way different students learn with different disabilities, uhmm the more professional development we have the more we learn how to deal with this things. if we are talking about engineering design part we are talking for most about a tool that a teacher did not have and your basically giving him an additionally tool to what they are already coming with to try to be successful	Professional development is basically giving that student population recognize and enhancing their skills finding a new way to do something be more effective in the classroom so that students have better test scores grabs the concepts better, or giving you a new set of tools to deal with diverse learners. we are talking about engineering design part we are talking for most about a tool that a teacher did not have and your basically giving him an additionally tool to what they are already	Defination of PD –helping giving that group of student/ teacher /individuals identified some form of skill/ helping them recognize skills. Enhancing their skills It may be also finding a new way to do something, seeking to be more effective and efficient in delivery of lessons in your classroom. PD can be done so that students can have better scores as a result of teacher participating and being exposed to PD. Pd is geared toward giving a teacher some additional tool to what they are already coming in with

Key:

Code: This column will be used to label and code emerging themes in the data.

ID: This column will be used to represent a unique identifier of interview respondents

Q#: In this column, the number of the question on the interview guide that was asked to elicit the participant's response in a given row will be recorded.

Line: A very important column that will allow sequencing of interview text to be able to quickly locate and track interview information with the interview.

Data: This column will contain the actual text from the data, divided into meaningful segments.

Notes: In this column, the researcher records, their personal notes, hunches, insights etc

Memo: In this column, researcher reports own thoughts about data.

The table was designed to have columns and rows containing data, initial notes, my reflection, and codes. This process helped me embark on writing memos to further break the data and understand what is going within it. Strauss and Corbin (1990) defined memos as the researcher's record of analysis, thoughts, interpretations, questions, and directions for further data collection. Charmaz (2002) explained that memos can range from free writes about the codes to tightly reasoned analytic statements. Through memo writing qualitative researchers elaborate, process assumptions, thoughts, and actions that are included in their codes.

In writing the memos I jotted down my initial thoughts using active terms to define what was happening in the data sets from each case. This step helped me to keep on questioning the data as I analyzed it further, reflecting, and immersing myself in to the whole process. I noted down my immediate thoughts and reflections of interviewee responses, recording what I thought the data was telling me in the notes section of my data table. I next embarked on reducing repetitive codes to eliminate redundancy. Hycner (1985) pointed out that it was important to note the actual number of times a code that elicited relevance to the study was listed since that might indicate some significance as to how important that particular experience was to the participants. Having this in mind, I took note of units to be eliminated, and those that would be retained. I then clustered units of relevant meaning into themes, constructed new theme labels, and classified units under these new themes. This strategy helped refine any initial categories that I had 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 memo writing linked coding to the writing of the first draft of the analysis; it is the intermediate step that moves the analysis forward. In addition to comparing the interviews and formulating follow up questions I devised categories defining the properties of each, providing examples and specifying what made it to be what I thought it was evolving to be. This step directed me to build a code book that consisted of evolving categories, subcategories and descriptors to further help me in categorizing and analyzing data that will describe a process for preparing technology education teachers to teach engineering design concepts in the context of technology education. Further, Charmaz 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.

Denzin (1998) posited that upon finishing analysis of data, the researcher is confronted with a mountain of impressions, documents and field notes. The qualitative researcher therefore faces the difficult and challenging task of making sense of what has been learned from the data. Denzin referred to this task as interpretation. Patton (2002), Denzin (1998), and Wolcott (1994) stated that interpretation allowed the researcher to translate what had been learned into a body of textual work that communicated the findings of a study to the reader. Having this in mind, I embarked on the writing process to transform analyzed data to a readable form. I employed descriptive realism writing style as described by Denzin (1998) and Wolcott (1994). In descriptive realism the writer attempts to approach writing without imposing their beliefs, allowing the study participants descriptions and experiences of phenomenon being investigated to speak for itself.

Validity and Reliability

Merriam (1998) postulated that all research was geared toward producing valid and reliable knowledge in an ethical manner. Unlike experimentalist research where comparison and statistical aggregation of data are performed to draw inferences that give a broad, generalizable set of findings, qualitative methods generally produce thick descriptive detailed information about a much smaller number of people without the use of statistical methods. Patton (2002), Merriam (1998), and Eisenhart and Howe (1992) stated that the emergence of qualitative methods in educational research continues to pose new questions on how to account for validity and reliability.

Validity, generally defined as the trustworthiness of inferences from data has always been an issue of great concern in qualitative research designs. According to Hammersley (1990), validity meant truth interpreted as to the extent to which an account accurately represents the social phenomena to which it refers. Lincoln and Guba (1985) argued that the concept of truth was an elusive one. They posited that truth is the familiar, a claim which is consistent with some other claim known to be true, it is accepted at face value and is a consensus among individuals acting in conformity with moral standards. Lincoln and Guba further stated that there was no benchmark from which truth can be tested for reliability against some external norms. The assumption here is that, truth can be thought to be consensus among informed individuals and may not correspond with objective reality. Lincoln and Guba (1985) argued that reality is a multiple set of mental constructions made by humans. This might mean that human beings make up their own truth, therefore there is no surety of the truth, and hence no specified benchmark from which valid observations can be made and reported.

Merriam (1998) postulated that one of the assumptions underlying qualitative research is that reality is holistic, multidimensional, and ever-changing; it is not a single, fixed, objective phenomenon waiting to be discovered, observed, and measured. Merriam further stated that the qualitative researcher is interested in perspectives rather than truth per se, and it is the researcher's obligation to present a more or less honest rendering of how informants actually view themselves and their experiences. According to Patton (2002), different perspectives of truth and the nature of reality constitute paradigms or world views based on alternative epistemologies and ontologies. Therefore, people viewing qualitative findings through different paradigmatic lenses will react to and interpret research finding differently. To this end, Merriam (1998) posited that when reality is viewed in this manner internal validity is a definite strength of qualitative research. Merriam further stated that it was imperative to understand the perspectives of those involved in the phenomenon of interest, to uncover the complexity of human behavior in a contextual framework and to present a holistic interpretation of what is happening.

Internal Validity

Internal validity is the extent to which one's findings are congruent with reality. Patton (2002) defined internal validity as the degree to which scientific observations and measurements are authentic representations of some reality. From a positivist perspective reality is fixed, waiting to be found and can be measured. On the other hand, the qualitative paradigm views reality as, multidimensional, and ever changing (Dewey 2004). Merriam (1998) suggested that there are basic strategies that can be used to ensure internal validity in qualitative research. These are (a) triangulation, (b) member checks, (c) long-term observation, (d) peer examination, and (e) researcher's biases. I attempted to adhere to Merriam's (1998) suggestions to achieve trustworthiness and credibility of findings of this study.

Mathison (1988) observed that good research practice required the use of multiple methods, data sources, and researchers to enhance validity of findings. Merriam, (1998) posited that triangulation is the use of multiple investigators, multiple sources of data, or multiple methods to confirm the emerging findings. Miles and Huberman (1984) stated that triangulation is supposed to support a finding by showing that independent measures of it agree with it or at least, do not contradict it. Denzin (1978) outlined four types of triangulation as a research strategy: (a) data triangulation, (b) investigator triangulation, (c) theory triangulation, and (d) methodological triangulation.

For this study I used data triangulation. Data triangulation refers to using several data sources. Investigator triangulation involves more than one investigator in the research process. Methodological triangulation refers to the use of multiple methods in examination of a social phenomenon, and theoretical triangulation is the use of several theoretical perspectives to examine a given phenomenon.

I conducted member checks by sharing transcribed transcripts with participants of this study. Merriam (1998) described member checks a process of taking data and interpretations back to the people from whom they were derived and asking them if the results are plausible. Guba and Lincoln (1985) indicated that the use of member checks was a crucial technique for establishing credibility of a study’s findings. I worked closely with my research committee member who was well versed with qualitative studies and contextual learning. I shared with him my work as it emerged every fortnight. He offered me valuable insight into my findings and suggestions on how I could continue developing the study. Merriam (1998) referred to this process as peer examination. This is where the researcher asks colleagues to comment on the findings as they emerge. The use of multiple analysts helped mediate my subjectivities and increase the adequacy of my interpretations. I clarified my biases by writing a subjectivity statement which is presented at the end of this chapter.

External Validity

External validity is concerned with the extent to which the findings of one study can be applied to other situations. In other words, how generalizable are the results of a research study. Merriam (1998) posited that qualitative case studies possessed high internal validity however the question of external validity was still a big issue for this mode of inquiry. According to Burlingame and Geske (1979) and Yin (1994) external validity could be demonstrated by use of many cases to study the same phenomenon. For example, the use of a multicase or cross case analysis, use of sampling, predetermined questions, and specific procedures for coding and analysis. These procedures enhance the generalizability of findings of a qualitative study. In this study, to enhance external validity, data was collected from two different sites, one site was located in the south eastern United States and the second site was located in the west coast of the United States. In addition, predetermined questions in the form of a semi structured questionnaire were used as a guide to conduct and collect participants' perspectives of engineering design workshop at the two sites.

Lincoln and Guba (1985) suggested that qualitative researchers can improve the generalizability of their findings by providing a rich, thick description of the data and findings, so that anyone else interested in transferability and replicating the study would have sufficient information to work from. Merriam (1998) further stated that another way of improving generalizability of a study's findings was conducting a cross-site or cross-case analysis, and describing how typical a program, event or individual is compared to others in the same class so that readers could make comparisons with their own situations. I incorporated Lincoln and

Guba's (1985) and Merriam's (1998) suggestions. In analyzing the data for this study, I compared the differences and similarities among the participants and sites. This not only generated categories within and across participants and sites but also the generalized relations among them. In addition, thick descriptions of each site, participants' profiles and perspectives have been detailed with quotes from interview transcripts to elicit participant experiences of and thoughts about the workshops.

Reliability

Reliability refers to the extent to which a researcher's findings can be replicated in similar situations (Merriam, 1998). Gall et al. (2003) defined reliability as the extent to which other researchers would arrive at similar results if they studied the same case employing the same procedures as the first researcher. Merriam (1998) argued that reliability and validity are inextricably linked in the conduct of research. She stated that it is impossible to have internal validity without reliability. Further, Merriam posited that a demonstration of internal validity amounts to a simultaneous demonstration of reliability. Conversely, she affirmed that any qualitative study findings would be considered more valid if repeated observations in the same study or replications of the entire study have produced similar results.

On the other hand, Bednarz (1985) stated that qualitative research seeks to describe and explain the world as those in the world construe it. He argued that there is no bench mark by which to make repeated measures and establish reliability since a concept may be interpreted differently. To this end, Merriam (1998) stated that achieving reliability in a qualitative study is difficult and replication will not yield the same results. However she suggested that researchers could ensure that their are results are dependable by, firstly, explaining the assumptions and theory behind the study, their position about the group being studied, their criteria for selecting the study participants and a description of the participants, and the social context from which data was collected. Secondly, using multiple methods of data collection and analysis, triangulation and thirdly, developing an audit trail. An audit trail is a detailed description of the methods, procedures, and actions a researcher used to arrive at their findings.

In this study, I provide at length, in-depth details of how I prepared to conduct this study through IRB submission, a detailed description of participants and site selection, data analysis procedures, and explanations of how categories were derived. Descriptions of theoretical frameworks guiding this study are also presented.

Subjectivity Statement

In this section, the researcher discusses how data trustworthiness will be established by giving insight into their role as a researcher and how a triangulation strategy will be implemented.

Researcher's role

Bogdan and Biklen (1982) argued that qualitative researchers are concerned with the effect their own subjectivity may have on the data they produce. Goetz and Lecompte (1984) posited that case study research is one of the few modes of scientific study that capture different aspects of human experiences into the research frame. Because the primary instrument in qualitative case study research is human, all observations and analyses are filtered through one's worldview, one's values, ones perspective. This is an important factor in this study, since my prior knowledge about engineering design may influence the abstraction process during data collection and analysis.

I was educated as a teacher, taught industrials art education in my native country of Kenya and was well versed with the faculty conducting the workshop having attended NCETE meetings. Therefore, I can relate to both faculty facilitating the workshop and the technology teachers in attendance. Currently, I am a full time doctoral student in the College of Education, Department of Workforce Education Leadership and Social Foundations at the University of Georgia. My research interests focused on engineering design, technology and teacher Education.

Presentations at national conferences, graduate studies, and a committed faculty to look up to at the University of Georgia, have inspired me to want to build a career in teacher education with a focus on issues related to technological literacy, adult learning and leadership development. I seek to conduct research and find ways that can help improve and incorporate new instructional methods through problem solving strategies, program changes, and simulated environments that can allow individuals to make connections to real world and work situations that meet the goals of the learner and organization. It is my intention to not only help improve individuals' daily work procedures, but also to organize workshops that demonstrate these concepts, thereby allowing them to implement action plans that will assist them in following up on new materials and practices.

I have also conducted a study that sought to identify the concept of engineering design, the key features of the engineering design process, and the critical elements that should be assessed in an engineering design activity in the context of technology education. As noted by Strauss and Corbin, (1998) all assumptions of preexisting theories are subject to potential skepticism, and therefore, must be scrutinized in light of one's own data established theories are always a part of any researcher's history. Therefore, my previous experiences with engineering design activities, research interests as well as my preparation as a teacher may highly influence my thoughts towards how these workshops are being administered as well as the content being delivered. In this study, I attempt to let the data drive discovery; however there may be instances of bias for example, imposing already predetermined categories.

Summary

In this chapter, I have outlined the strategies I undertook to plan, conduct, and analyze the data that emanated from this study. In brief, this chapter described the design and nature of qualitative research and pointed out why qualitative case study design was an appropriate research methodology to conduct this study. This multisite case study was conducted at two NCETE sites that offered professional workshop activities that focused on integrating engineering design in the K-12 curriculum. Due to accessibility of workshop location, convenience sampling was used to select participants of the study. Data collection procedures included in-depth interviews, observations, artifacts, and video footage. Collected data and artifacts were analyzed for themes and patterns. Additionally, video footage and field notes informed the analysis process. The chapter concludes with a discussion of how validity and reliability were achieved as well as a subjective statement that guided my biases as I drew inferences from the data.

CHAPTER 4

PARTICIPANT DESCRIPTIONS

Introduction

The participants in this study were professors facilitating engineering design workshops and participating, middle and high school teachers at two NCETE sites. The interviews took place in the summer of 2006. The first NCETE site to be visited was Eleven University, six high school and middle school teachers who taught technology education at three counties near the university, and two professors facilitating the workshops were interviewed. The second site, Twelve University, five high school and middle school teachers involved in Math, technology and science subjects in their respective schools participated in the study. Figures five and six (see page 80) provide demographic information of the participants in this study.

Figure 5. Participant demographics at Eleven University.

Name	Gender	Certification Path	Total Years Teaching	Grade Level Teaching
Barno	M	University	Not available	University
Harifa	M	University	15	9-12
Kicheko	M	University	Not available	University
Letaa	M	University	4	9-12
Ludiga	M	University	5	9-12
Moko	M	University	5	6-8
Tembo	F	University	3	9-12
Thande	M	University	6	6-8

Barno

Barno, an assistant professor is a calm soft spoken reflective individual. He is the undergraduate coordinator of the Trade and Industrial Education program at Eleven University. His primary responsibilities include teaching, advising, research, and service to the educational community. Additionally Barno also serves on the committees for curriculum, and spring career expo for the school of technology. At Eleven University, Barno teaches introduction to drafting technology, introduction to technology, and computer aided drafting. He is an encourager, an advisor, and a role model to his students

Barno's leadership and student motivation have been recognized by state officials and professional organizations. The International Technology Education Association (ITEA) has recognized and awarded him the Teacher Excellence award for his state. This award is given to individuals who have displayed innovative teaching and dedication to the field of technology education. His professional degrees include a doctorate degree in education, a master's of science in technology education and a bachelor of science in industrial technology and electronics. Currently, he is working with his colleague Kicheko, in facilitating the engineering design workshop at Eleven University. Barno knows, through his efforts and teaching expertise he can help his students and the general community appreciate the role of engineering design in their lives. He sees the workshop as an opportunity to continue developing his community and hopes that his teaching of engineering design concepts to secondary technology teachers would eventually bring to his department freshmen who have been introduced to basics of engineering design.

Harifa

Harifa is a soft spoken gentleman who looked composed and relaxed through out the workshop session. He seemed friendly and was ready to interview with me at my convenience. Harifa has a degree in Industrial technology and 15 years of teaching experience although he has not been teaching technology education throughout. Harifa got into teaching through coaching, he was asked to coach track and field in his first teaching job. Currently, he teaches 9th and 12th grade classes in one of the high schools' around Eleven University. Most of the classes he is assigned to teach are introductory classes in communication, manufacturing, transportation, and electronics. He also teaches fundamentals of technology and education systems, and drafting.

Harifa explained that his fundamental of technology class is module driven, however students did not always like all the modules presented in this class. At such instances he has to come up with projects that will engage his students if the modules fall short. Harifa sees this as extra work in a time constrained school year that administrators highly scrutinized students test scores performance. Harifa is very critical of the education system; he thinks that school administrators and parents pay more attention to test scores forgetting that students have to learn other skills. He fears that most teachers are rated by how well their students perform in these tests. He sees this as a setback for technology education and the engineering workshop he is attending. Harifa argued that he will not have adequate time to implement what he is learning at the workshop the way he would like too because of test score pressure and limited time to perform technological projects in a given school year.

The technology education activities that he performs with his students depend on what class he is teaching. He tries to incorporate a lot of different concepts and hands-on activities in his technology education classes. Harifa seeks to develop projects that have graphic communications and design, and video production aspects. He believes such directives are fun to do because his students are more receptive to practical classes and they always want to do something. Harifa gets a feeling of satisfaction when he helps his students manufacture products they can take home with them. He also directs them to develop some type of portfolio they can use when they apply to college.

Kicheko

Kicheko is one of the professor's facilitating the engineering design workshop at Eleven University. He holds a doctorate in technology education in vocational and technical education with emphases in manufacturing, communication technology, and instructional technology. A masters' degree in vocational and technical education, emphasis in curriculum development and a minor in curriculum and instruction and a bachelor's in industrial arts education, with an interest in manufacturing.

Currently, he is a full time professor, in the technology education, trade and industrial education department at Eleven University. His duties at the university include teaching all of the training and development courses in his department. He anticipates teaching any or all of the technology education courses, including all of the systems and design courses in the future. His research interests include: diversity, curriculum integration, and problem solving as a major outcome for technology education students. He has published in numerous articles in technological journals and received grants to conduct research in the field of technology education.

Letaa

Letaa was very accommodating and interesting to interview. He is on his second career. He worked as an industrial designer before he decided to be a technology education teacher. Letaa did not begin his teaching career in technology education. He taught at a community college for a while before accepting a high school teaching position. Letaa completed his master's degree from Eleven University a couple of years ago, and plans to add a doctorate degree to his teaching credentials. However, he is still not sure in what field he wants to major. Letaa stated that he liked research work and was highly interested in my study, and what I was doing to help move the field forward. At the time of this study he had just completed his fourth year of teaching at a high school located in one of the three counties around Eleven University where he teaches Grades nine through 12. At his school they focus on two areas of Technology Education: drafting, and engineering. The technology education program at his school is designed to prepare students to pursue post secondary education, or join the workplace either in a computer technician role or architectural drafting environment.

At the moment, Letaa teaches fundamentals of technology to ninth grade students, communications systems to 10th grade students, and computer engineering classes to 11th and 12th grade students. He does a lot of standard projects with his students. For example, they create bridges, and design gliders from materials they bring to school or can find around the classroom. They test their designs to see how far they can get them to fly, after which he asks his students to improve on the flaws they noted. In his computer classes he deliberately disables computers and asks his students figure out how to fix them with his guidance. Letaa stated that this exercise was designed to help his students learn how to assemble a computer and learn what goes into purchasing an efficient computer without spending too much money. He seeks to encourage his students to be good researchers and resourceful.

Ludiga

Ludiga talks with a lot of passion and commitment with regard to his teaching and experiences with his students. He is talkative and many a times I had to cut him short so that we could be focused on the interview. Ludiga is a retired systems software engineer who decided to go into teaching a couple of years back. To get certified to teach technology education, Ludiga enrolled at Eleven University as a lateral entry teacher. He took the course requirements and the praxis exam in order to be licensed in his state to teach technology education. Ludiga has been teaching technology education for five years now. He teaches fundamentals of technology education, principles of technology, communication systems and computer engineering to grades nine through 12 at a high school in one of the three counties near Eleven University. Most of his classes have multiple grades in them, so it a mixture of students from each grade class. Ludiga is very critical of the way students with behavioral issues are assigned to technology education classes. He was quick to add that his goal was to create a conducive learning environment for each child who walks into his classroom. Ludiga spoke highly of his work with his students. He seems to enjoy what he is doing with his students. His commitment to teaching was evident in the way he talked.

Moko

Moko is a middle school teacher working with sixth, seventh, and eighth grade students who meet for his class at the same time. The school Moko teaches is located in Nickel County, 15 minutes from Eleven University students. This is the end of Moko's fourth year as a public school teacher. He taught technology and computer systems for five years at a technical community college before joining the public schools system. He received a bachelor's degree in vocational industrial education and a second major in history, qualifying him to teach machining technology. Unfortunately at the time he finished his studies there were only two schools that offered machining technology in Nickel County and they did not have any openings. Moko was instead offered a middle school position to teach technology education, so he went back to Eleven University and took more courses which gave him a second certification to teach technology education.

Before embarking on a teaching career, Moko was in the service for 20 years where he was a service repair technician. During his years in the military he did a lot of hands-on activities in the machine shop, wood shop, canvas, glass, body and vendor, welding, and radio repair. He is happy that all of those things he did during his years in the military directly relate to everything that he teaches and the NCETE workshop he is attending.

At his school he uses modules in his classroom. Each module has projects depicting some form of engineering design process, but of low quality. Moko explained that these modules consisted of 12 units that go on in his classroom simultaneously. He likes the activities he performs with his students. Moko talks with a lot of pride giving details of how these projects mirror real life situations. For Example, they test different shapes of cars; with gas prices soaring today, he believes what his students learn in this exercise is not going to change the price of gas but help them know that the shape of a car has a lot do with how much gas it is going to consume.

Moko requires his students to keep a journal where they document daily thoughts and notes about their projects. He used to grade these journals but found that his students become more involved if he let them grade it themselves. Moko argued that this made a student to become more involved in what they were doing and proud of their work, forcing them to be honest in their grading. He keeps a sharp eye on how his students grade their work. Moko tries to instill a sense of responsibility to his students and life values. He sees this as important and believes the more he cultivates this in his students the more their creativity and inventiveness is exposed and nurtured.

Tembo

Tembo is a bubbly, energetic, jolly person. She teaches sophomores, juniors and seniors in manufacturing systems, transportation, structural systems and fundamentals of technology at Sony Point High School in Blake County which is located approximately 20 minutes from

Eleven University. Tembo's path to teaching has been interesting. She chose to go into teaching after being laid off twice in various companies. Tembo has spent 20 years in manufacturing and computer programming industries. She has expertise working with database systems. She stated that if one had pools and pools of database on four different computers and needed it all pulled together and compiled so that all 20 million records came out as a one page summary for the executive, she could perform the task with ease. She has also run her own retail enterprise selling crafts and likes doing her own home repairs. During her working years in the industry she spent most of the time working within various departments and was the liaison between the information technology people and the personnel on the shop floor.

Tembo is a lateral entry teacher and is certified in social studies, her first degree major subject. She never knew that technology education existed until she interviewed for a history job at her children's high school. The principal asked her is she had ever heard of technology education and she answered no, asking what it was. The principal explained to her what technology education entailed letting her know that there was opening at the school and would gladly offer it to her if she was interested. Tembo agreed to the position because it sounded like a lot of fun than history. Although Tembo does not have any traditional technology education training, her equipment and tools operation skills are self taught. She stated that she had tremendous understanding of technological processes, controls, and information, that is, the problem solving, trouble shooting and debugging that has to go on in solving a design challenge. She began teaching in a trailer that did not have any tools or facilities. Through her efforts, the administrative officials have provided her with a better classroom and teaching facilities.

Tembo has spent a lot of time figuring out how technology education works and where it came from. She is involved with the State level rewriting curriculum. She is trying to extend these efforts beyond her own school system, to figure out what's going on who is doing what so that she could help move technology education program in her school district into the 21st century.

Thande

Thande is a middle school teacher working with sixth, seventh, and eighth grade students at one of the schools in Blake County. He sees himself to be fortunate because if students start in his technology education program, they will end up finishing in his class, having them for all three years. He believes that this is important, and an opportunity to track his students progress through out the entire program.

Thande sees a teacher as an enabler. Thande believes as a teacher he has to direct his students to a probable answer whenever he presents them with a challenge or activity. However, he stated that he was lacking on this aspect, he was not an enabler probably because of his military background. Thande served in the military for 10.5 years as a tank manager. This position required him to be a teacher. He strongly believes the military taught him how to teach and his degree taught him what the curriculum encompassed. Thande strongly believes that the different military courses he took while serving taught him how to teach a soldier at the most basic level to get the job done. Sometimes this military attitude spills into his teaching. He looks at the task at hand and sometime tells his students that they cannot complete the challenge. He does not care what grade level they are or their ability, and that's the core of his teaching, which sometimes irritates him.

Thande earned his bachelors degree from Eleven University majoring in graphic communications and received his Master's degree in technology education from the same institution. His decision to teach was somewhat interesting. When working on his undergraduate, he was helping one of his professors who was being evaluated by her department chair, a couple of her peers and the dean of the school. They saw how he was teaching and they approached him asking if he had ever thought about teaching in public education. He laughed at the thought, stating that those kids will make life hard, six months later he ended up teaching.

Figure 6. Participant Demographics at Twelve University

Name	Gender	Certification Path	Total Years Teaching	Grade Level Teaching
Abantu	M	Information not available	20	9-12
Benta	M	University	9	9-12
Limpo	M	University	Not available	University
Mesop	M	Technical/Vocational college	14	6-8
Mitaro	M	University	1	9-12
Petro	M	University	Not available	University
Visupu	F	University	2	9-12

Abantu

Abantu teaches high school, grades nine through 12. He is soft spoken and took his time to reflect before he answered my questions. He has teaching credentials in industrial arts, physics and Math. Abantu declined to tell me how he was trained to be a teacher but discussed how he ended up being a teacher. He stated his being a teacher had something to do with the Vietnam War and a draft lottery that was based on his birthday. He chose teaching over going to war.

Abantu teaches electronics and circuit analysis, digital and robotics, programming, and engineering practices. He stated that the programming class he teaches is very basic and the language is easy to learn. This class introduces his students to programming language. Abantu is an interesting person; he takes his students learning process and future very seriously. He tries to prepare them for college work by teaching them at least the first three chapters of college material for each course he teaches them. He does this by taking a college book related to the classes he teaches, and introduces the material in a way he thinks will help his students. He sees this as a strategy to prepare his students for college work.

According to Abantu, once his students get admitted to college and decide to further what he has taught them in a given field, they at least have some basic introduction and can easily adjust to college work the first three weeks of school. He also has laboratory classes that relate to each discipline. In these labs he divides his students into groups giving them a project that will last them the whole semester. Abantu does not believe in giving tests, he argued that tests make students be programmed to merely give answers to questions asked without giving the questions a deep thought. Abantu stated that when students answer test questions they are simply completing missing parts of given statements. To him giving tests do not contribute to helping the student learn new material. He instead prefers to give his students a blank paper, and ask them to write down 10 questions they do not know.

Benta

Benta teaches mathematics at Lodwar High School in Luther County, located 10 minutes away from Twelve University. Benta enrolled for a civil engineering degree at University of California – Berkley for a year and later changed his major to Mathematics. He has been a teacher for nine years and enjoys working with students. Benta is the only teacher in this workshop who is not from Jambo Unified School District. He is attending this workshop because his school district is planning to start an engineering academy and his superintendent and principal thought he was a good candidate to start the program.

Benta math teaching schedule changes year to year, last year, he taught geometry classes, this year, he is teaching Algebra II where he has a mixture of ninth, 11, and 12th grade students. The other two classes Benta teaches are senior math classes. In this class he discusses a little bit of geometry, circles, and triangles, a little bit of algebra, equations, fractions, decimals and percentages. Benta stated that in this class he does not really get into any in-depth math, but prefers to discuss more real life issues that involve mathematical concepts. They talk about balancing a check book, buying a home and mortgages, and car loans. He tries to prepare them for life at junior college or university. He thinks that he is a good choice to begin the engineering academy in his district and his strong background in mathematics will be helpful in designing engineering/technology programs. He hopes he will create programs that will encourage his students to be engineers and not end up changing major from engineering degree objective like he did. He is quick to add that he does not regret changing his degree objective he found the engineering classes to be boring during his college years.

Limpo

Limpo began his academic career at Twelve University nine years ago after spending five years in consulting practice. His background is Civil Engineering. He holds a Ph.D., Master of Science and Bachelor degrees in the field. He facilitates the engineering design section of the workshop at Twelve University. His teaching interests cover the full range of geotechnical engineering and include laboratory testing to determine soil strength properties, soil dynamics, slope stability, foundation engineering, and stability of earth structures.

This is the second year he is facilitating the engineering design workshop at the University. For this workshop Limpo prepared a design challenge that seeks to expose workshop participants on how engineering concepts can be infused into areas prone to earth quakes. He is using shake tables to emphasize "real-life" problems and solutions to demonstrate his lesson. He enjoys teaching concepts on earth retaining structures and geotechnical earthquake engineering

His areas of research interest are in seafloor engineering, soil nailing, engineering education, and nondestructive testing of pile foundations. He has applied his geotechnical engineering skills to a wide array of local projects in his state.

Mesop

Mesop is an elderly man who was proud to inform me that he started teaching when technology education was known as industrial arts. He considers himself to be an industrial arts teacher, although they call it technology education at the moment. He teaches sixth, seventh, and eighth grade students at one of the schools in Jambo Unified School District in the west coast of United States. Mesop sees his teaching of industrial arts to be in between technology education, Math, Engineering, Science and Achievement (MESA) program. He thinks that technology education and MESA espouse similar concepts and he tries to combine them in his classroom. He strongly believes that this helps his students learn some Math and Science concepts through hands-on projects. Some of the projects that he does with his students include designing and manufacturing airplanes and mousetrap cars among other things that are of interest to his students.

Mesop has an interesting mix of background having served in the military for 15 years after which he went back to school seeking to change careers asking himself what he would like to do for a living. He looked at the career book and everything available and decided being an industrial arts teacher would be a pretty good thing, it would be easy for him to do because he liked it. Besides he could rest during the summer time. Mesop also liked being in woodshop and metal shop and loved anything to do with his hands so his saw this as a good thing, and teaching was for him.

Mesop enrolled in a vocational school to train to be a tool designer, and had to change to machining techniques because he never got along with his teacher at that time. In high school, he took a year of machine shop, drafting and tool design, and two years of welding. Mesop also took industrial arts classes where he studied woodshop, metal shop, auto shop and electric shop. He is enjoying the workshop however he does not like the mathematics involved with engineering design and sees as a challenge when he introduces engineering aspects to his middle school students.

Mitaro

Mitaro comes across as an individual who likes engineering sciences. He portrayed the image of a scholar who had just gotten himself a faculty position at a college of sciences. His studious and inquisitive nature was displayed through out the workshop session at Twelve University. He has just finished his first year of teaching and he looks forward to his second year.

Mitaro was the last person I interviewed with at Twelve University. We got acquainted quickly and started conversing. Upon completion of his master's degree in electrical engineering Mitaro enrolled for a one year master's of arts in teaching program in the college of education at the University of Southern California. The credentials he received were in Physics and Mathematics. He has always wanted to give back to his community and thought teaching was a good way to do that. He teaches electives that are primarily aimed at the ninth and 10th grade level students, and also other electives that are aimed at the 11th and 12th grade level. He teaches computer programming, an introduction course, a computer science advanced placement course, a digital electronics course which is project based, and robotics to all the four grades.

In his robotics class, he teaches his students on how to build and design robots using a kit, while emphasizing knowledge of design and the essential mechanics required. Mitaro thinks the design challenge and the activities that they are performing at the NCETE workshop fit naturally into the robotics curriculum at his school. Particularly, he sees the hands-on component of the workshop important and transferable to his students. He strongly believes that it's imperative that his students have a hands' on component.

Petro

Petro has 30 plus years of teaching. He has served as the associate dean of the school of engineering and technology for six years and as chair of the department of technology for another 6 years at Twelve University. Petro holds doctorate in curriculum and instruction, a master's in vocational education, and a bachelor of arts in industrial arts. He has been a member of the faculty at Twelve University for 25 years.

Petro's area of specialization is design, with a focus on architecture, electronics packaging and process plant design. He believes that design isn't a separate discipline, but rather the "front end" of manufacturing or construction. He also has an interest in elementary technology education and technology education for students with disabilities. His technical areas of interest include architecture, computer aided design, process plant design, and design models. He also has interests in the general field of education including program articulation, assisting teachers with inclusion programs for students with disabilities in technology education. He is working with Limpo to facilitate the engineering workshops at Twelve University.

Visupu

Visupu is a young teacher who has been on the job for two years. She attended Cal State University in Long Beach to get her teaching credentials. She is multilingual and enjoys the fact that she can help kids to whom English is their second language. She teaches ninth grade students. She stated that she had a good bond with her students and treated them like adults avoiding talking to them as if they were high schools kids or little kids. Visupu performs different experiments in her classes, she discusses the concepts of physics and how sciences correlate with life. She also teaches earth sciences and incorporates it into her physical science classes. She does earth quake simulations and she was delighted to find out that the workshop she was attending had similar projects although at a higher level. She loves challenges; she likes to be shown new things, things that she has never seen before that she can use with her students. She thinks this workshop has done that for her. Visupu believes that it is important for students to be exposed to engineering concepts and future workshops should not only be designed for technology education teachers.

Visupu described her school going days and her love for sciences. She stated that the science programs and camps she attended at school never introduced her to the engineering design process and way of thinking. The same happened when she attended college. Classes that exposed students to technology and engineering were never instilled upon her and she thinks it is unfortunate that a lot of students still go through what she went through if they are not in a technology based program. She is enjoying every bit of the workshop and beliefs that she can help take her students a step further and expose them to engineering concepts.

Summary

In this chapter I have introduced the 15 participants of this study, two were females, and 13 were male. Four of the participants were university professors whose area of specialization was teacher preparation in technology education and engineering design practices. The remaining 11 participants were middle and high school teachers, eight of whom taught at the high school level and the other three at middle school. All participants were involved in technology education program, science, and mathematics subjects in their respective schools and had been certified to teach at high school and middle school level in their respective states. Their teaching experience levels ranged from one to 15 years.

CHAPTER 5

RESULTS AND DISCUSSION

Introduction

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.

The study was guided by the following research questions:

1. How are the two sites similar or different?
2. What factors influence teacher educators' choice of content and instructional activities when conducting engineering design professional development workshops?
3. What theories of instruction and learning do teacher educators use to teach engineering design in professional development workshops? What influences teacher educators' choice of theories?
4. How do teacher educators conducting professional development workshops evaluate the effectiveness of the workshops in meeting stated objectives?
5. What are the reflections of secondary technology teachers' experiences with respect to content, delivery methods, strengths, and weaknesses of the engineering design workshops? What do secondary technology teachers say are the strengths and limitations of each program?

6. What would secondary technology teachers like to have changed in engineering design professional development workshops with regard to content and instructional activities? What are the reasons for the changes?
7. What implications for subsequent programs can be drawn from data collected at the two sites?

Data Collection Procedures

As a qualitative researcher, I was the instrument of data collection. I conducted interviews with faculty facilitating engineering design workshops and secondary technology education teachers at Eleven University and Twelve University. Interview questions were based on a semi-structured guide and focused on an understanding of faculty and workshop participants' experiences and perceptions of engineering design workshop content and administration. In addition, the interviews explored why faculty chose certain methodology and engineering design activities, and what influence they expected these activities will have on workshop participants learning experiences and teaching of engineering design concepts at the K-12 level.

Four workshop facilitators who were faculty members at the both Eleven University and Twelve University were given a semi structured interview guide (appendix A) to help prepare for the interview. These one-on-one interviews were scheduled at the convenience of each facilitator. All the facilitators invited to participate in the study chose to have interviews in the laboratory where they were administering the workshop. We chose a quiet corner in the lab and conversed for about 30-40 minutes. The interviews were all digitally taped. Additionally, I took short notes during the interview. These notes helped me to probe further eliciting responses that I might not have obtained if I had only followed the interview guide.

Secondary technology teacher interviews lasted about 30 minutes. Each teacher was presented with a semi-structured interview guide (appendix A) that followed a format similar to workshop facilitator guide. The interview sessions followed a similar format to the facilitators' interviews. We found a quite place in the lab and had a discussion about their experiences in the workshop. These interviews were also digitally taped. Findings of the faculty and secondary technology interviews are presented case by case in this chapter. Individual case findings of faculty and students of each site are presented in the form of "faculty member said" and "teachers said" in order to help facilitate the communication of participants' perceptions of their experiences in the engineering design workshop. The individual participant case findings were further examined for commonalities and themes. Emergent themes grounded in the purpose of this study and overriding research questions are also presented. Quotes from participants are used throughout this section to illicit the findings from participant verbatim transcripts.

Participants Findings and Discussions

Workshop Facilitators

Barno and Kicheko facilitate engineering design workshops at Eleven University, while Limpo and Petro conduct the same workshop at Twelve University. To conduct such a workshop, facilitators should be conversant with technology education problem solving process as well as engineering design process. In this study, the four professors at both sites shared the same conviction with regard to the difference between engineering design and technology education problem solving process. They argued that engineering design was similar to technology education problem-solving process however; engineering design had some added components, that is, predictive analysis and optimization.

According to Kicheko, engineering design was unique from other forms of design. Engineering design is tied to criteria identified by the design team ahead of time. Some analysis goes into determining which alternative solution is optimal and there is a look back system that verifies that the selected design work to be developed can be compared to identified criteria, meets specifications, and will operate within stated constraints.

According to the NCETE Website (2005), professional development workshops are designed to help infuse aspects of engineering design into technology education design activities at the K-12 level. Facilitators at both sites worked toward this objective by inviting high school secondary technology teachers to attend and participate in professional development design activities. Petro, one of the facilitators at Twelve University explained at length the amount of time his team puts into planning for the workshop. He explained that the workshop was divided into three parts: spring semester session, summer workshop sessions and fall/winter session. He said:

> our workshops are broken into 3 main segments. Segment one is the six spring workshops. During the spring workshops, teachers are exposed to math, science, and engineering. The second phase takes place in the summer and they are provided with an engineering design challenge. The third segment is follow-up in the fall or winter

Barno and Kicheko at Eleven University also had the same format for their workshops. Barno reported that the first phase of professional development in the spring semester focuses on building teachers' mathematics and science skills by having them complete hands-on engineering challenges. The second phase required teachers to apply what they have learned in the first phase toward identification of a solution to a major engineering design challenge. At the time of this study, workshop participants’ were solving an engineering design challenge called the Water Tower Project. The third phase was assessment; this was conducted by visiting the schools where participants taught, to observe how teachers were implementing engineering design concepts learned at the workshop in their classrooms. According to Kicheko, teachers who attended the workshop completed 100 hours of professional development.

I sought to find how workshop facilitators defined professional development; what was professional development from their perspective? Barno stated that the professional development they were conducting at Eleven University was geared toward giving a teacher a tool in addition to those they already possessed in order to be successful in infusing engineering design into their teaching habits. This is a concept that technology education teachers do not possess. According to Barno professional development is an alternative route to provide secondary technology teachers with this additional tool.

Barno defined professional development as:

> Giving that student or teacher population, helping them recognize and enhancing their skills… its finding a new way to do something to hopefully be more effective in the classroom with students.

In other words, Barno views professional development as a process that is administered to teachers or persons to improve some form of expertise they already possess to enable them be more effective and efficient in performing their work related duties.

Kicheko, Barno’s colleague at Eleven University described professional development as follows:

> Professional development is something that allows you to extend your potential as a professional. As one becomes good in what they are doing and gaining experience other things are starting to change around them, and so if you put yourself into a structured opportunity to learn about those that things that are changing then you will develop yourself as a professional. In other words it’s the thing that the life long learner will seek out as a professional.

It can then be stated that Kicheko assumes that professional development is pursued by the lifelong learner with specialized skills in a given field. With change in this given field, this individual then seeks re-training to enhance their skills/ knowledge of new direction their given field is taking.

According to Petro at Twelve University, professional development parallels inservice. He argued that the word “inservice” was no longer fashionable, however it was used to distinguish between inservice and preservice. Petro stated that preservice was preparing teachers to teach in a classroom, before they actually started teaching, while inservice meant providing additional development to these teachers after they had started teaching. He argued that professional development for teachers was synonymous to inservice. He remarked, “It is a way of providing teachers with new teaching tools, after they've entered the profession.”

On the other hand, Limpo an engineer by profession explained professional development from the eyes of his field of trade. He stated that professional development was learning what the state of practice or the state of art in the field was by keeping up to date through taking courses, attending seminars, and practicing engineering by conducting research. Descriptions of professional development as portrayed by workshop facilitators in this study revealed that professional development is a lifelong learning process that was sought by individuals who possessed some form of specialized training in a given field or occupation. Through professional development these individuals continuously build upon the skills they already have to effectively and efficiently perform their daily life activities.

The state of practice in a field reflects the changes that have taken place throughout the subject over the years. The field of technology education has evolved through out its inception in the early 1970s. Curriculum instructional activities have been standardized to reflect ITEA standards of technological literacy. Students are involved in design projects that seek to enhance their understanding of technology, its components and its implications to man. In this study, participants described in detail, factors that influence their choice of content and instructional activities that are geared toward enhancing the ITEA standards as well as achieve the goals of the workshop. Content describes the topics of interest to be discussed during the course of the engineering design workshop. According to Barno and Kicheko, workshop content activities are organized around engineering design and related literature.

The context where these activities are conducted is also a very important part of encouraging the learning that is being sought. Kicheko further described a Delphi study that he conducted with Barno, to determine what engineers and engineering educators believe should be taught to high school students regarding engineering. They identified that technology /engineering design activities should be designed to develop and nurture the following attributes in individuals: (a) development of interpersonal skills e.g. teamwork, attitudes and work ethic, (b) ability to communicate and write ideas verbally (c) design and manufacture solutions within given constraints (d) ability to brainstorm and generate ideas (e) assess product design and troubleshoot technological devices (f) understand the role mathematical and scientific equations play in designing solutions (g) have an understanding of various engineering fields, and (h) develop, keep and update a portfolio.

Barno added that the engineering design activity that workshop participants were working on at Eleven University was named “Clean Reliable Water.” This activity required workshop participants to use the engineering design approach to design, develop, and implement an inexpensive, working, scale model of a water system that will automatically supply a water tower tank with water from a reservoir. To develop such a project, Barno and Kicheko relied on the expertise of an engineering professor who conducted the engineering part of the workshop. This is what Barno said:

> Having the engineer on our team whose expertise is in electronics, a lot of our professional development activities have electrical components just to take advantage of his know-how.

On the other hand, the professors at Twelve University also relied on the expertise of the engineer on their team to design workshop content that depicted aspects of engineering design.

This is what Petro said about the engineering design expert on his team and the design activity he created:

> He did a spectacular job. He not only designed an engineering design challenge that perfectly fit the bill. To us, perfectly fitting the bill meant it was…….. it had predictive mathematical analysis.

Twelve University workshop engineering design content was designed around Limpo research interests. Limpo believed that engineering as a subject could be taught better to high school students, and help them understand predictive analysis and related engineering design concepts. He hoped that his efforts would encourage students' to have a desire and an interest to pursue a career in either an engineering or technology related field.

The design challenge at this site was named "Quake Ed." Workshop participants were required to work in design teams and construct simple model buildings from steel threaded rod and metal tubing fastened together with wing nuts. Each team was then to use a computer and a digital sensor to measure the buildings movement when subjected to an earthquake simulation on shake table. The team was then required to predict the buildings movement and compare it to the sensor's recorded data, upon which they recommend the optimal building height to be constructed within specified constraints.

At both sites, engineering design instructional activities were dependent on the expertise of an engineering design faculty who facilitated the engineering design challenge. These instructional design activities were devised after a period of planning, thorough review of literature about trends and issues in the field, and conducting research studies. In this study, the professors stated that engineering professional development activities for technology education teachers should be tailored not to introduce new content in terms of construction or manufacturing content but enhance these lessons by infusing the engineering design component. This process could be achieved by introducing the engineering design content to be taught and designing projects in a contextual manner. Magolda (2004) pointed out that knowledge existed in context and was judged on evidence relevant to that context. Teaching in context seeks to illustrate real-world examples offering students an opportunity to reflect and make connections of what they are learning to real life situations. In the same vein, Schell (2001) posited that contextual teaching enables teachers to relate subject matter learning to real world life experiences, helping students transfer acquired knowledge and problem solving skills learned in school to other life contexts.

Schell and Schell (in press) stated that this approach to teaching promoted relevance to learners extending that recognition to educational opportunities that promote reflection and meaning-making. Schell and Schell further argued that the greatest benefit of contextual learning was helping students move into higher levels of reflection and expertise at earlier phases of their career. Wilson and Cole (1991) stated that reflection provided students with an opportunity to look back over their efforts, complete a task, and analyze their own performance. Amulya (2003) posited that reflection was an active process of witnessing one's own experience in order to take a closer look at it, directing attention to it and explore it in greater depth. In view of these observations, it can be argued that when people reflect, they think and recall information from their funds of knowledge. In other words, they gain insight into issues at hand constructing information to make meaning of phenomena. Reflective analysis is an important concept in learning. Wilson and Cole (1991) stated that reflection helped bring meaning to activities that might otherwise be more rote and procedural. They cautioned that ignoring reflection in teaching may lead learners not to learn how to discriminate in applying procedures, fail to recognize conditions where using their knowledge could be appropriate, in addition to transferring knowledge to different tasks.

In this study, faculty discussed various theories of instruction they believed played a role in their teaching of engineering design content to workshop participants. Petro posited that teaching is a mixture of what works for you at that point in time, it is eclectic in nature a mixture of different instructional styles depending on what one was teaching. He believed that this kind of workshop should be centered on project based learning. According to Petro project-based learning required students to learn around a central challenge, project or problem to solve. He further stated that it is team based cooperative learning, hands-on or applied type of learning that was engaging and active leading to the realization of a tangible outcome. It is deeply into problem solving and development of critical thinking skills guiding students to ask a lot of "what if" questions, that is, What if we try it this way? What if we do this? What if we make it longer? What if we make it taller? These "what if" questions as outlined by Petro may be seen to be conversational tags that invited approval from others to generate mutually acceptable accounts to solve challenges. Such tags helped build on each others reports so as to generate narrative continuity, request each others to fill out particulars, or send affirmation to others accounts (Gergen, 1994).

With regard to theories of learning and instructional approach that guided his teaching of engineering design concepts during the workshop, this is what Petro said:

> You start teaching, you start developing methodologies, based on theories that work. And, you stop worrying about which theories you're leaning back on, you know…. I'd say, probably, eclectic would be more honest…. It's just a mixture of ……. different things….. whatever is appropriate for the moment.

Limpo shared the same ideologies, his preferred instructional approach was to lecture and have students work in groups depending on the engineering content he was teaching.

I further asked Limpo and Petro what they had learned from last year's workshop that they were doing differently in the current workshop. Petro explained that in the first year they offered four math sessions as well as three for physics however, in the current workshop this has been reversed. They have four physics sessions and three for math; because they realized that they were giving workshop participants a lot of extra math that they did not need and cutting them a little bit short on the physics.

Workshop facilitators felt they were rushing through some things and workshop sessions were turning out to be more of theory based. In addition, they were disappointed by the number of teachers who had successfully implemented aspects of engineering design into their classroom. To meet some of the shortfalls encountered and noted in the previous year, workshop facilitators tweaked the engineering design challenge added more materials as hand outs for the teachers. Limpo stated that he had worked with a graduate student on the design challenge and tested all different combinations of things trying to figure out what would work best. As a result he was able to decide which materials would work best to illustrate what he was trying to teach workshop participants. The facilitators also required the workshop participants to read widely on engineering/ engineering design process prior to coming to the summer workshop.

Barno and Kicheko shared the same sentiments as Petro and Limpo when I asked them about lessons they learned from last years' workshop.

Barno said:

> By the time we got to the water tower last year we had only three days left, it was really rush rush rush the groups completed but they were really pressed…We taught them how to calculate uhh friction of water moving thru the PVC pipes, so it was very thorough. This time we didn't hit them with that much, so there is a little less math this time.

This is what Kicheko said in relation to changes they had made from lessons learnt in the first workshop.

> Last year we tried to have them do, three heavy duty engineering design challenges during the summer phase but it pushed them too much. They did not have enough time to do their portfolio, so this year we have one challenge which we simplified to be done in one half of the workshop, second half would be pure planning time on how to implement the engineering design process into their existing curriculum.

Barno further explained at length the instructional approaches his team employed to achieve the goals of the workshop. He stated that most of the design activities and learning that took place was an independent type of constructivist learning, especially in the spring segment where they used a web platform to conduct discussions with workshop participants. During the summer segment, Barno explained that learning was a cooperative effort, among the participants and professors. Workshop participants worked in teams to complete assigned tasks. They pulled from each others strengths and weakness. He was quick to distinguish what he called cooperative effort from cooperative learning. Barno described cooperative learning to be a strategy where students worked in teams to research on a given topic and later present it to their colleagues, helping each other understand a given subject. He further described cooperative effort as a form of collaborative learning where student work together in teams to solve a given problem.

Kicheko, on the other hand, mentioned theorists like Jean Piaget, Jerome Bruner, and John Dewey who had written books and other materials that played a major role in his teaching of engineering design content to technology education teachers. He argued that Dewey's idea of doing something in context, that is, learning by doing was highly motivating. He believed that technology education as subject opened up a lot of opportunities for other learning to take place. This allowed students to relate situations of what they might have done in the past or to realize what they may have understood coming into a program was wrong. Kicheko further referred to the use of backward design process as described by Wiggins and McTighe, which begins with the end product in mind.

Kicheko stated that these strategies portrayed cognitive constructionism at work and mirrored the standards for teaching technological literacy. According to ITEA (2001) the Standards for Technological Literacy: Content for the Study of Technology (STL) Standard eight states, "To become literate in the design process requires cognitive and procedural knowledge to create design, in addition to familiarity with the processes by which design will be carried out to make a product or system." This statement reflects the importance of cognitive and constructionist theories which are task-oriented in teaching the design process. Constructivism emphasizes the building of ideas that occur in people's minds when interacting with the environment, promoting creativity and originality in design. Additionally Rogers (2002, p.10) posited that:

> Cognitive learning consists of the recall and recognition of knowledge, comprehension, understanding the material, exploring it more actively, the application of the comprehended knowledge, using it in concrete situations then exploring each new situation by breaking it down into its constituents parts (analysis) and building it up to new concepts (synthesis) and finally, evaluation in which the learners come to assess the new knowledge, to judge its value in relation to the realization of their goals.

Constructivists view learning as the result of mental construction, students learn by fitting new information together with what they already know. This theory suggests a number of points about teaching and learning. According to Magolda (2004) knowledge is complex and socially constructed; self is central to knowledge construction; and authority and expertise are shared in mutual knowledge construction among peers. Bruner (1990) stated that as a theory of teaching it addresses four major aspects. Firstly, predisposition towards learning. Secondly, the ways in which a body of knowledge can be structured so that it can be most readily grasped by the learner. Thirdly, the most effective sequences in which to present material and lastly good methods for structuring knowledge should result in simplifying, generating new propositions, and increasing the manipulation of information.

In this study, teacher educators employed several learning strategies; lectures, discussions, practical demonstrations and applications. Notably they utilized constructivism as a theory to help encourage workshop participants discover and relate principles by themselves. In other words, design challenge activities and learning was situated in participants' experiences. According to Magolda (2004) such strategies give learners' a base from which to construct knowledge connecting their experiences to the task at hand. At both sites the teacher educators designed the workshop sessions to provide the participants with an opportunity of being key players in the learning process. In other words, workshop participants participated in generating meaning and understanding of the engineering design process.

Bruner (1990) further described the task of the instructor to be that of translating information to be learned into a format appropriate to the learner's current state of understanding. He argued that learning is optimized when the student is aware of the process that he or she is structuring, inventing and employing. This process is called metacognition: an aspect that Kicheko believed played a big role in his facilitation of the workshop sessions. Teacher educators in this study therefore, sought to provide workshop participants with an opportunity to take part in decision-making about the outcomes, goals and objectives of the workshop. They provided a learning environment which supported participants by connecting workshop participants' experiences to workshop content and design challenges through a variety of techniques that espoused critical reflection of participants' workshop experiences. These teacher educators fostered discussions, group and team work, and hands-on experiences allowing workshop participants to reflect and evaluate their ideas in the learning process.

Evaluation and Assessment of workshop goals and objectives as well as participants progress is a difficult task. In this study, assessment meant looking at, and evaluating how workshop participants were implementing and infusing engineering design concepts into their technology education classrooms. This was achieved through a variety of ways. All the four professors interviewed expressed the need to visit workshop participants in their classrooms and share with them experiences and difficulties that the participants had encountered on the course of infusing aspects of engineering design into technology education curriculum activities at the K-12 level.

According to Petro, assessment is conducted in two stages. Workshop facilitators at Twelve University gave a pre-assessment that sought to assess how well the workshop participants mastered the concepts they discussed through out the summer workshop sessions. The second bit of assessment involved paying a visit to one of the workshop participants at their school. According to Petro, such a meeting presents an opportunity to highlight a program that's doing really well. The chosen participant is referred to as the host teacher and they are selected on the basis of successfully infusing and implementing aspects of engineering design into their teaching. Petro stated that all the workshop participants are then invited to attend and observe the host teacher program, discuss and share ideas.

Limpo had this to say about assessment:

> Last year is after the summer workshops we took the new, the second year cohort to the high school of the first year cohort and we went thru a whole discussion round table discussion oh how they implemented design challenges, what worked, what did not work what would be done different, I think that was a real important part of the assessment.

At Eleven University, Kicheko explained that participants were provided with a rubric with established criteria. Participants were required to examine established criteria before designing a probable solution. Upon choosing a solution and designing the product, participants were expected to then compare the solution to those criteria. Barno described assessment as a process. The main goal was to help workshop participants experience success with assigned project and mentally getting them to accept the value of engineering design and what it can bring to their classroom. Workshop participants were also required to keep a portfolio, that included things like notes and book references they had been given through the first segment in spring. Participants were required to document in the portfolio, their thoughts on what their team could have done better, how they would modify assigned project to suit their classroom situations and teaching, and any other relevant information. Barno referred to this as reflective practice. McAlpine and Weston (2000), and Pultorak (1993) stated that reflection was essential in teacher preparation programs because it was seen as a vehicle by which teachers become thoughtful about their experiences. Risko, Roskos, and Vukelich (2005) stated that reflection was valued by teacher educators for its power to invite critical thinking about one's belief and developing knowledge and its potential for providing markers of conceptual change. In this study, workshop facilitators sought teachers to take control of their learning by asking them to reflect on the workshop activities. Kicheko stated that reflective analysis was used to help teachers assess their performance toward workshop project.

In terms of evaluating the professional development content and facilitation of workshop activities, workshop participants were provided with a survey at the end of the workshop. This survey sought to find out participants opinions and suggestions on what they think the components the professional development should be, and what could be done better. In the fall, that is, the third segment of the workshop, workshop facilitators' visited participants' schools to observe workshop participants' implementation of engineering design concepts into their teaching as well as students working on engineering design projects. Kicheko stated that this year they intended to collect copies of teachers engineering design lesson plans/projects and implementation plans, video material, portfolios, and students standardized technology educational test scores.

In this study, assessment and evaluation of workshop goals and objectives as well as participants progress has been described as a process, which involves the assessed and assessor. Both parties work together in a systematic way to achieve a common goal. Evaluation and assessment should be on a continual basis, there are no right and wrong answers. Participants are assessed in terms of how well they solved the design challenge and transferred the concepts to their classroom. Their opinions and suggestions are also taken in to consideration as part of the assessment process. Through these opinions, workshop facilitators get feedback on their delivery of engineering design content, workshop planning, and organization. In addition, this helps them to plan for future workshops.

Workshop Participants

In this section of this chapter I present findings from interview sessions with middle and high school teachers at the two NCETE sites selected for this study. The interviews took place in the summer of 2006. Eleven participants of whom eight were high school teachers and three taught at the middle school level attended the workshops. The average teaching age was five years and all the participants had gone through higher institutions of education to meet their state's teaching requirements. All participants in the study were invited to attend the workshop session after being nominated, and chosen by their school superintendents, or principals, upon which, they received some form of correspondence from workshop facilitators.

The workshop participants took a lot of interest in their professional growth as technology education teachers. Word about this workshop excited a lot of teachers, several of the participants believed that professional development was a means of improving their teaching skills and learning new ways of doings old things. Virtually every participant said in one way or another that their primary reason for choosing to attend and participate in this workshop was the possibility of its impact on their teaching and students. Thande, Visupu, Mitaro, Moko, and Tembo all shared the same sentiments upon finding more about the workshop. Thande, a middle school teacher who attended the workshop at Eleven University, did so because the workshop was to help further his technology education knowledge and teaching skills. He believed that the workshop content had the elements he was looking for and would take his technology education program further.

This is what Thande said:

> Having attended several workshops in the State and talking to colleagues, our technology education program is under attack because we are not in the tested areas. Upon consulting with Kicheko and his explanation of the workshop, this is what I am looking for such a workshop that introduces some engineering concepts gives our program more validity and reliability.

He maintained that professional development meant learning something new that he could make a connection to what he was already doing in his class. Thande stated that if a professional development session did not have any connection to what he does, then the session was just another class he took. He believed professional development sessions should be designed to take prospective participants to be successful in what they do. Moko was happy to hear the kind of activities they would perform in the workshop. He exclaimed that he liked the hands-on activities having worked as a repair technician for 20 plus years. He thought that his students will enjoy whatever concepts and ideas he had learned at the workshop once he implemented them in his classroom. Mitaro a first year teacher stated that, curriculum leaders he had been working with at the time to improve instructional activities in his school district, informed him of the engineering workshop strongly recommending it to him. He further received an email from his principal who suggested and urged him to attend the workshop. Mitaro gathered relevant information about the workshop from professors at Twelve University upon which he thought it was a great opportunity to learn and enhance his teaching skills.

In the same vein, Visupu, one of the participants at Twelve University, stated that she got information about the workshop from a colleague. She contacted Petro one of the professors facilitating the workshop at Twelve University who provided her with more information about the workshop. Visupu was happy with what she heard Petro say about the workshop content, she was exuberant and shared her experience during the interview.

Visupu exclaimed:

> I love it I really like this workshop, and I really want to teach my students about it and I think its important that they not only incorporate engineering into technology education classes, but also into biology, earth sciences, and chemistry teaching them on how to mix the two disciplines instead of making them separate.

When asked to define professional development, Tembo a lateral entry teacher, offered two perspectives. She said:

> I believe professional development is an opportunity to teach me how to be a better teacher, I am lateral entry and I am not well versed in the language of teaching that whole pedagogy…….. another thing is that these workshops shows me how to physically do the projects that like we have done here, how to do a water tower project how to break it down into its components, thinking about all the things that you have to have, recognizing that it won’t be a one day project, rather a 6 weeks project uhmm thinking about having the time to work with my peers to figure out what can go wrong, and ideas on how to solve that problem.

In a professional development workshop, participants are exposed to new information that seeks to change their mode of practice. In such a workshop, content maybe organized around new technologies, curricula, or new teaching methodologies in a given field. In this particular workshop, the main objective was infusion of engineering design into technology education activities. Therefore, teacher educators organized the workshop content around engineering design activities and how it could be infused into technology education classroom activities. In other words, teacher educators were not providing new information to participants of these workshops but rather teach them how to incorporate and enhance their teaching of technology education by infusing some aspects of engineering design into their teaching.

At the two NCETE sites, the engineering design content differed in terms of design challenge presented to participants. At Eleven University, participants were required to work in groups and design a working model of a clean water supply tower. This tower was to be designed to draw water from a reservoir. The project limited participants to using two five gallon buckets. One five gallon bucket was to act as a reservoir and the other five gallon water bucket was the water tank. The participants were required to devise a system that would pump water from the reservoir to the water tank. They had to design the tank to hold a minimum of three inches depth amount of water in the reservoir and cut off when it was three inches before getting to its full capacity. If water in the reservoir dropped below the three inch mark, a pump that sends water up the tank comes on. In other words if the water is three inches from the bottom of the tank the pump should automatically turn on and this would fill the water tank, when the water gets three inches from the top, the pump should automatically turn off. Participants had to develop a circuitry system that operated two switches that controlled the pump motor. One of the switches was to be placed in the reservoir and the other one in the tank. Both switches were to be designed to either allow current to flow or break the circuit depending on the level of water in the tank.

At Twelve University the design challenge was different. It was called QuakeEd and workshop participants were required to construct a building that would with stand an earthquake based on a simulated environment. The challenge presented asked them to design three buildings that would be 12 storeys, 18 storeys or 24 storeys that would withstand an earthquake of a magnitude of 8 on the Richter scale. The question read, “A client specifically thinks the 24 storey one is ideal and needs to know the best building to construct.” Participants were required to construct model versions of these three building using two columns and a mass, conduct tests and inform the client which building was economical and would withstand the earthquake. They used a shake table to simulate an earthquake, after which they measured and figured out which building would collapse and which one would be the best based on the constraints or parameters presented. To this end, workshop participants at both sites had varied views of what the engineering design workshop content should be.

Mesop, who believed that he was the only remaining shop teacher in his school district thought the content was fine and relevant to his city. He said that everybody who lives there had experienced an earthquake, “This is earthquake city here, you know.” He further stated that a lot of students do not know all the dynamics that go into designing buildings that could with stand an earthquake. However, Mesop thought the math was too much and too way above what his students would be eager to learn, this is what he said:

> the delivery of the content is fine, except for math. It's just totally math. You know, we have the shake tables and everything and it's all right. But, you know, for me, I didn't want to take a math class. And, that's what I'm taking. Basically, that's what I'm taking. It is a math class. I know I'm supposed to be taking this to include math. They said it was going to be more engineering than math. More doing, more hands-on stuff.

Benta a math teacher, also shared the same sentiments with Mesop. When asked to share his thoughts about workshop content, Benta quickly pointed out the presence of a middle school teacher as a participant in the workshop, who he thought would have a hard time transferring the content being taught to his classroom. I was prompted to ask him how he would use the content in his classroom. He reported that he would use the concepts he had learned in the workshop with his Algebra II students. Benta further stated he liked the mode of delivery used to disseminate the workshop content, however he claimed to have known everything, “the physics was good, the math was good…but for me, I knew everything already, so it was kind of…..not, I wouldn't say, a waste...but it was redundant.” Abantu commented that it had been worth his time participating in the workshop. On a scale of one through four, he rated the content to be a three. He stated that he had been exposed to some new things which he could incorporate into projects that he already does.

Visupu was enthusiastic and highly interested in the workshop content. She taught earth sciences and conducted a lot of earth quake projects with her students. Visupu reported that she had always wanted to include engineering design aspects into her projects and the workshop content was perfect.

This is what Visupu said amid her excitement about the workshop:

> This workshop had earth sciences and engineering which is perfect. So I came here I love the topic and I am not afraid of any of the content. I didn't know all of the content when I came here and I wasn’t afraid to learn it. I can’t say that I knew everything 100%, I can't say that I knew all the definite little physics and math stuff that is involved, but now I know it enough to teach my 9th graders the idea of engineering design and things like that. So I think the content was perfect it was not difficult and it was not too easy either. It challenged me it was nice, I like to be shown something that I have not seen before and now 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.

At Eleven University, Ludiga, a retired software engineer who had embraced teaching with a passion four years ago, liked the idea of trying to plan out and deliver modules that will enhance engineering design process. He thought that the content of the workshop should comprise a lot of examples with a ton of potential lesson plans that emphasize infusion of engineering design aspects into technology education. Ludiga was quick to add that such lessons plans have got to be more simplified for the introductory high school kid and probably be performed during a classroom period.

Letaa did not like the content of the workshop. He wanted part of the content to be structural design related and not have everything hinged on electronics. He acknowledged that the workshop content was so because the facilitators might have designed lessons based on their strengths and interests. He argued that such content alienated those who did not have an interest in electronics. Letaa said he would like future workshops to have a greater variety of projects than the electronics based project. Harifa confessed that he could not take the project they were working on in the workshop into his classroom without watering it down. He however, said that he would take and incorporate engineering design concepts in all the projects he does with his students.

Moko, Tembo, and Thande stated that their expectations were met in the workshop. Moko stated:

> I like the hands-on, and I think that's what most students will enjoy. Not only do you go somewhat in depth about some of the things you do as far as research goes and some decision making process but you get to do, you know to see that it really works and I think with kids that's going to be very important because they learn by seeing.

Tembo commented:

> I think the content is pretty good, I would have preferred a little more organization at the beginning so that I would know where we were headed with this stuff it didn't really dawn on me what the intent of all the sessions were until when I was putting it all together earlier this week. Am not sure we have achieved all the goals that we set out for but we have certainly learnt a lot about the engineering design process. I feel more confident with that cycle than I would have ever had otherwise.

Thande remarked that he liked the project they were working on. It challenged him, going home mentally tired constantly thinking of ways to modify his engineering design team solutions.

With participation in professional design activities, change in practice is expected. In this study, one of the key goals of NCETE workshops as explained on their website is to infuse engineering design aspects into technology education. NCETE will achieve this objective by offering professional development to secondary teachers that will initiate change in program design, curricular choices, and student assessment. NCETE hopes that such a venture will impact learning and implementation of classroom activities related to technology education and engineering at the K-12 level.

If implementation and infusion of engineering design aspects is a targeted outcome of participants' attendance, how did these participants decide what was meaningful enough to them to follow through on implementation? The discussion that follows presents data shared by the participants on their initial thoughts of how this workshop will influence their implementation of technology education design activities with engineering design as the focus in their classrooms.

Nearly all participants agreed that workshop facilitators had discussed some issues that participants would face when adapting the design challenges in their classrooms. Mesop, Thande, Letaa, Moko, Visupu, Ludiga, and Harifa all agreed that the content presented at the workshop would have an impact on the way they conducted their design activities. Mesop who did not like the math part of the workshop, said that he would get together with the math teacher at his school to help simplify some concepts and make them easier for his students. He further stated that in his classroom he already performed most of the things they had discussed in the workshop, however in his technology education design class he performed only three to five steps unlike the eight engineering design steps they had covered in the workshop. He concluded by saying that he will try to include some of the steps that were missing in his technology education design activities.

Thande was delighted with the whole workshop and affirmed that he envisioned how the engineering design process worked and it would give his students that breadth of knowledge to fully understand how to be successful. He stated that this process provided some sought of connection, some understanding of what the product was going to look like even before they started working on it.

Letaa who had worked as a designer in industry and was on his second career said:

> I hadn't even given it some thought until this workshop. I was pretty much a gut instinct kind of guy. A designer…I designed something…And, having been here – specifically with the design matrix, and analyzing some of the solutions. I guess it really opened my eyes to making more educative decisions in choosing solutions.

Letaa hoped to teach his students how to use the design matrix and engineering process instead of their instincts when making decisions about design solutions. Moko, whose classes were module-based, stated that the workshop had provided him with an opportunity to enhance the modules in addition to developing a project that relates to other tasks they conduct in his design classes.

Harifa was affirmative that the workshop will enhance his teaching capabilities. This is what he said:

> It has enhanced it. It definitely has enhanced it. The engineering concept thing makes you look at things more analytical, whereas from a technical phase, we look at things more physical. Technology field, you're looking at more hands-on work, in the engineering field, you're looking at things more analytical. So it forces us not only to look at the making the product, but the theory behind it.

Visupu, who was enthusiastic about the whole workshop, confessed that she would not do a lot of the activities that had been suggested in the workshop, but will use the concepts or the design behind these projects and incorporate them in the laboratory projects that she currently does with her students. As much as Ludiga agreed that the content of the workshop will make him consider incorporating some aspects of engineering design into his classroom, he posed a lot of rhetorical questions with regard to the content that was being taught and what he was expected to infuse in his classroom activities.

This is what Ludiga said,"

> Oh, yeah! Sure! I don't disagree with that. My question here is really though, just what are the engineering concepts they are trying to teach? Are they trying to teach us, electronics? Are they e trying to teach us evaluative procedures, like the matrix for deciding which potential solution, are they trying to teach us how to use the tools? Are they trying to teach us how to sketch out a raw design and implement, or fabricate that with the materials that we're given? Are we allowed to go out and come up with other materials that we know about that are better?

Mitaro and Tembo, on the other hand, had different views with regard to what to take back to their classrooms and if the workshop enhanced their ability to solve problems. Mitaro, who has an engineering background said that the workshop hadn't improved his problem solving skills however the challenge presented was a new type of problem that he had learnt to solve. As far as transferring the design challenge into his classroom, Mitaro posited that the second part of the workshop achieved this purpose. He stated that the engineering design aspects they had discussed fit very well with his robotics curriculum. On the other hand, he believed that for the other participants, it was not as close of a fit especially those who taught other subjects not related to technology education. It would be difficult to make changes to suit ones teaching and students.

Tembo who had worked in manufacturing and programming for a long time where problem solving and debugging were the norm said, “I have been doing this process in my whole life but not in a formal fashion, I think the formalization of the whole series of steps helped focus on the pieces I was missing.” She stated that the engineering design activities they had performed in the workshop will not enhance her problem solving abilities. Tembo thought having an understanding of the process and applying the concepts to surreal life problems was the key to infusing engineering aspects to the classroom. In the classroom situation, Tembo said that she will be able to get her students to think differently and instinctively, when solving design challenges.

Having discussed what they thought worked and what did not in this workshop, in addition to concepts they would infuse into their classroom, I asked the participants to share what they would like workshop planners to know and do for the next cohort of engineering design workshop attendees. Harifa recommended diversification of workshop activities, this is what he said:

> I think all four of our discussion questions were electronic based. It is good if that’s something that you understand. Some teachers’ expertise might be structural, transportation or communication. They should have an activity in each area that workshop attendees can relate too and apply their strength.

Letaa suggested that participants should be surveyed as early as possible to target teacher needs. Thande voiced that he felt that workshop planners should understand all venues of what the project should be. He also commented on the online portion discussion of the workshop. He posited that this session should be planned to be synchronous rather than asynchronous. Thande argued that asynchronous discussions felt like answering a bunch of emails rather than having a conversation with colleagues. He further stated that the online discussion portions should be more in-depth and not related to materials they would cover in the workshop but what the teachers were doing in their classrooms. The discussions should probably center on asking teachers how they could come up with an engineering design process for their classroom projects. Thande proposed that workshop planners should ask prospective attendees what projects they were working on in their classrooms. Such a process would help gather data on different projects from which workshop design challenges could be developed.

Two teachers, Benta and Moko indicated that workshop planners should take into consideration whether to invite and have middle school teachers participate in workshops. If they chose to invite middle school teachers then they should develop engineering design content that could be easily transferred to a middle school setting. Moko a middle school teacher summed his frustration of workshop content when he said:

> Most of the focus here is geared towards high school we have one or two teachers here including myself that teach in middle school, if we had some stuff that related to middle school a little bit more that would be great.

Thande who is also a middle school teacher suggested that workshop planners should have developed one particular project that depicted high school level material and another one to cater for the middle school teachers.

Abantu stated that America as a country relied heavily on foreign talent. He speculated that it will take more than NCETE engineering workshops to increase the supply of technical people in needed fields. Abantu suggested the inclusion of all minority groups in sciences would be a strategic move to keep America competitive. Ludiga, a computer software engineer by profession strongly suggested that workshop planners should limit the constraints of the workshop to materials provided. He claimed to have abused the privileges as soon as he found out he could go outside the set constraints. He said that such a situation opens up the given design challenge to ones specific background.

Mitaro, commended workshop planners for making sure that all attendees who had different educational backgrounds and professional preparation were provided with all the knowledge they needed to participate in the workshop before embarking of the design challenge. Second year teacher Visupu said that she did not have an idea that such a workshop existed. She felt that workshop planners should improve on the advertisement of the workshop in addition to inviting teachers from other fields.

Mesop, who believed that he was the only remaining industrial arts teacher in his district was very critical of the mathematical content presented in the workshop. This is what he said:

> Let the teachers know that it's math, I haven't done anything like the calculations here since I was in college, and it’s a little bit rusty for me. For the other younger people, they're fine with it because they're just out of school, but what I would like to see them do is to have the math broken down so that it would be high school, middle school, you know...and even lower. A lot of kids that are in high school are not even doing high school math.

To this end, I further probed the workshop participants to suggest one thing they would have changed about the workshop. While most participants expressed confidence with and enjoyment of the hands-on subject matter and academic content presented in the workshop, every participant found a way of expressing some changes they would have implemented as reflected in the following discussion.

Thande and Mesop commented on the math bit of the workshop. Mesop lamented throughout our interview session about the math sessions in the workshop. It was not a surprise when he uttered, “Math.” He stated as much as the math is important, it should be simplified and tailored to solving the design challenge presented in the workshop. In the same vein, Thande thought that the math should be simplified and be among the first sessions to be offered in the workshop because it was a vehicle to get you through the workshop design challenges. He also wanted to see the participation on all facilitators.

This is what Thande said:

> I think there is one main voice as far as the facilitators are concerned though we have other members that I feel need to pull in teach the mini lessons in their area of expertise. I think that's what I would have done different.

Letaa called for a greater variety of projects, while Benta thought the sessions were too slow and should have moved a little bit faster to include some other topics related to engineering design. Harifa and Moko suggested an inclusion of more middle grade staff. Moko further suggested making the workshop a little bit longer, especially during the spring segment during which they met only once a month. Mitaro, on the other hand suggested a shorter time period. This is what he said, "I think it would be easier to get people in here if you could fit all that material into a one week time commitment, instead of a two week time commitment. If it was 6 days instead of 11 days, it would be easier to bring in more teachers." Ludiga stated that he would have liked to see an instructor's working model of the design challenge participants were to work on prior to the workshop.

Emergent Themes

This study sought to find out a process of preparing technology education teachers to teach engineering design concepts in the context of technology education. The use of an interview guide structured the interview sessions however we did not follow the guide to the letter. Many a times we deviated from the guide as participants narrated their experiences as I probed whenever an occasion arose. The interview sessions yielded over 300 pages of data that I had to sift through to answer the research questions guiding this study. In addition, I spent a lot of time viewing video footage, reading the artifacts and workshop schedules from both sites looking for commonalities and themes.

Participant responses and additional material collected during the study led me 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.

Professional Development

The ultimate goal of NCETE is to infuse engineering content and design, problem solving, and analytical skills into technology education and to increase the quality, quantity, and diversity of engineering and technology educators. 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.

In this study professional development workshops were designed to help technology education as a field to direct its focus on engineering. Therefore, workshop facilitators organized the workshop content around engineering design activities and how it could be infused into technology education classroom activities. Teacher educators were not providing new information to participants of these workshops but rather preparing them to incorporate and enhance their teaching of technology education by infusing some aspects of engineering design into their teaching.

In other words, secondary teachers were being exposed to engineering design and ways that they could disseminate this new knowledge to their students in an easy, understandable manner. 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. Limpo posited that, "professional development was learning what the state of practice or the state of art in the field was by keeping up to date through taking courses, attending seminars, and practicing engineering by conducting research."

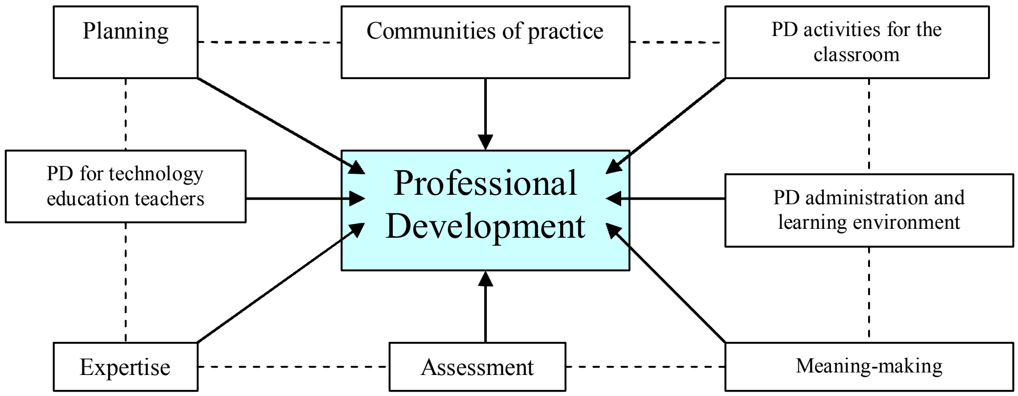
To most secondary technology teachers who participated in this study professional development referred to learning something new that they could help make a connection to what they were already doing in their classroom. Thande, Visupu, Mitaro, Moko, and Tembo saw professional development as an opportunity to be taught how to improve their teaching skills and become better teachers in their field. Thus, participants in this study viewed professional development as a lifelong learning process that was sought by individuals who possessed some form of specialized training in a given field or occupation. Through professional development these individuals continuously build upon the skills they already have to effectively and efficiently perform their day-to-day activities. In other words, professional development is a lifelong learning process that is necessitated and preceded by some form of change in a given field.

Nearly every participant said in one way or another that their primary reason for choosing to attend and participate in a professional development workshop was the possibility of its impact on their teaching and students. It therefore follows that, through professional development, individuals are prepared to adopt and adapt to changes in their given environment operation. They are also taught ways to impart and impact these changes in their daily activities to achieve intended longitudinal goals of professional development workshop. Visupu reported that the workshop was a success this is what she said with regard to her 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 reported that the hands-on activities in the workshop were very important experiences for kids, since they learned by seeing. It can then be argued that professional development is and should be an ongoing activity that is undertaken by practicing teachers to improve their knowledge and teaching skills as circumstances change hence positively impacting their fields of study, practice, in addition to students' learning experiences.

MacDonald (1992) suggested program content, clarification of goals, reasons for participation, students' reaction, support systems, program climate, and practical ideas and teaching methods as relevant areas to conduct successful professional development activities. In the same vein, Loucks-Horsley (1995) identified the following dimensions that support professional development activities: (a) focus on student learning outcomes (b) focus on individual and system development (c) inquiry into teaching and learning (d) focus on job embedded learning (e) focus on content and content–specific teaching skills
(f) driven by clear, coherent, long-term strategic plan (g) school direction and decision making (h) professional development as everyone's job (i) professional development for everyone, and (j) professional development as essential.

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

Figure 7. 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. This is the second year NCETE centers are conducting this workshop. 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.

Planning is key to strategic problem solving and identification of procedures that support the elements that contribute to a desired solution. To this end, planning can be described as an important contributing component to the success of designing solutions to challenges facing humanity. Petro 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.

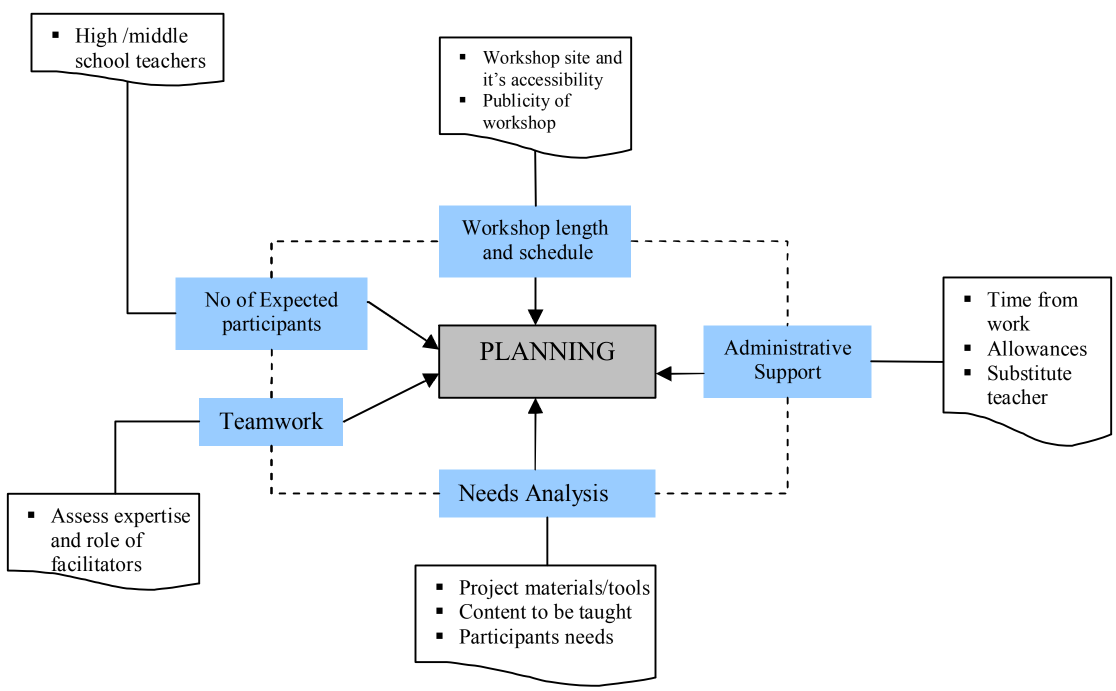
In this study workshop facilitators agreed that the summer session took a lot of resources to plan. Barno, Limpo, and Petro postulated that it may take three to five months to successfully plan for such a workshop. According to Barno, as soon as the summer segment is concluded workshop facilitators at Eleven University seek feedback on suggestions for improvement in readiness to plan for the next group of teachers. Sayer (1996) pointed out that professional needs are closely related to morale. He posited that there needs to be a shared sense of purpose across stakeholders for teachers and schools to be confident that their practice makes sense in the society. In other words, successful professional development sessions should be planned with group needs and interests in mind. Such needs are best determined through conducting a needs assessment.

To this end 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.

Upon identification of teachers, Kicheko added that it was important to seek administration support to enable teachers attend workshop without restrictions. Administrative support according to the participants of this study meant getting time off work to attend and participate in the workshops, having arrangements made for a substitute teacher to cover one's class when attending the workshop, and being paid some form of allowance to meet miscellaneous costs that's may be incurred as a result of attending the workshop. Figure 8 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.

Figure 8. Elements of planning that embrace engineering design professional development workshops as identified in this study.



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. Lave and Wenger (1991); Barab and Duffy (1998) and Wenger (1998) contend that people learn as they interact with and within a community of practice, gaining understanding while participating and shaping its history, assumptions, cultural values, and rule.

Wilson (1993) explained that learning is an everyday event that is social in nature because it occurs with other people. He argued that it is tool dependent because the setting provides mechanisms that aid, and more important, structure the cognitive process; and finally it is the interaction with the setting itself in relation to its social and tool dependent nature that determines the learning. In this study, a group of teachers and workshop facilitators who shared a common goal met and participated in engineering design workshop. These individuals sought to infuse engineering design concepts into the K-12 curriculum by working in teams, sharing and negotiating ideas hence meaning making to solve challenges that were designed to change their teaching practices. Secondary technology teachers chose to attend these workshops because of its intended objectives and outcomes. They all believed that attending the workshop will impact their knowledge of engineering design and teaching styles. Harifa, 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.
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 facilitators at Twelve University 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.

When asked to talk to about the design challenge and the opportunities it presented, several participants shared their experiences. Letaa posited that it helped to have somebody with some expertise in each group to help solve the design challenge. Petro voiced that professional development was a perfect integration tool to get science teachers, math teachers, technology teachers to work together in a community. Moko summed up the idea of working in a community when he said that everyone had to blend in, pulling on each other's strengths and weaknesses, bringing it all together, and sharing ideas to solve a common problem. Harifa took the idea of communities of practice to include his students when he said, "If you can teach kids the idea of team concept, and that when you're in a team, you tie ideas together, and before you know it, you start learning from each other."

Ludiga, a retired software engineer who had been teaching for five years stated:

> Learning from one another and supporting students is the goal, and it permeates all that the team does. Ours is not real fancy. When we set up our criteria matrix, we decided that we wanted out tower to be very strong and cosmetics didn't matter. We've got a solution now, that doesn't look pretty, but we have a proof of concept that meets all the criteria.

In this study, the concept of team work helps teachers share experiences and solve design challenges presented to them. Through such activities teachers have formed a community of practice within a larger community, that is, the workshop. Conducting engineering design professional activities by organizing a workshop centered on communities of practice concepts not only helps utilize allotted workshop time effectively but also provides an opportunity for participants' needs and problems to be addressed. Additionally, discussions and solutions to various challenges experience are nurtured and most importantly, teachers learn and know each other's priorities and values as they work together toward a common goal.

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. Additionally, Loucks-Horsley (1995) stated that educators have realized that, without the support of the organizations in which they work, teachers are often constrained from using their newly acquired knowledge and skills to benefit their students.

In this study, the two sites had similar managerial styles and operations. At Eleven University, 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."

According to Kicheko, a workshop facilitator at Eleven University successive administration of professional development activities meant taking lessons learned from preceding workshops and always looking for new ideas. He suggested coming up with activities that participants will enjoy doing, eager to learn the theoretical aspects, and could take back to the students. He was quick to point out that workshop participants appreciated sessions that will get the lesson across and were economical to implement in their classrooms. Letaa, a teacher who had taught for 4 years suggested that it would be of help before inviting participants, to survey them and find their strengths, weakness, and interests enabling facilitators to design a diverse group of activities.

On being asked about the scheduling of the workshop and allocation of participants to teams, Limpo, Petro, Kicheko, and Barno shared the same thoughts Barno said, “We had kind of a schedule in terms of just trying to bench mark them to get finished so that we can tell if we are behind schedule.” Kicheko was quick to say, “No they need to do their own schedule, they are following an engineering design process which is a schedule on its own.” Petro and Limpo at Twelve University did not have a schedule either but what they called a pacing guide, which helped participants finish workshop requirements by the end of the week. Petro said, “We did not tell them you know you should be at this point by 8 o’clock or 10 o’clock they worked at their own pace with our guidance.” To this end, Letaa said, “One of the things I liked is that we’ve had adequate time to prepare and test our solutions. I didn’t feel rushed in this workshop.” Mitaro, an engineer by training stated, “If you have some administrative support from your local site then you may be able to do some things that are a little bit unusual.” It can then be argued that when professional development programs create an environment that facilitates and supports teacher learning, and continue to support teachers in their endeavors to integrate new concepts and instructional strategies into their ongoing educational programs, then teachers can expand and elaborate their professional knowledge base and can begin to teach in fundamentally different ways (Borko & Putnam, 1995).

The idea of creating a learning environment that's informal and depicts a social context is encouraging and appreciated by adults. According to Lave (1998) social relationships experienced in real-world context make the best learning environments. In other words, through participation in a community of practice, learning and instruction can be approached from a hands-on project aspect. Gredler (1997) posited that in such an environment, the facilitator's role is to actively assist participants overcome obstacles by probing the limits of their understanding with difficult situations, and management of uncertainty that may arise as they complete tasks. Kicheko stated that he welcomed the idea of an informal learning environment because it gave workshop participants control of their own actions and decisions. This in turn helped them gain confidence in making decisions on their own. Barno exclaimed that the engineering design challenge and the informal learning environment they had created for the workshop was a vehicle to help teachers realize that the thought processes, team work, and skills developed in informal settings when solving engineering design problems could be transferred to their classroom environments. To this end participants in this study unanimously agreed the learning environment created by the workshop facilitators was be fitting 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.

Ludiga liked the workshop setting and hoped that he could have such a place for his classes at school he taught. This is what he said, “Well, it's great! I wish I had half the space in my school that I see here.” Thande recalled his past experiences at workshops, and said,

> I have been in some workshops where they say don’t use this, don’t do this its going to do that, that’s a fear instilling tactic, this environment was wonderful. I won’t say laid back but an environment that they wanted you to learn and take something away.

At Twelve University, Visupu who was enthusiastic about the workshop, she liked the laboratory they were working from. She also appreciated the field trips that were part of the workshop. This is what she said, “We have a place to do our labs, we have gone for a field trip. Even though Twelve University is far from our city, I think it’s very comfortable.” Benta echoed Visupu’s comment when he said, “this is a great place to come work, and the layout of the workshop is absolutely good.”

In view of this comments, Guskey (1995) stated that teachers’ attitudes and practices were more likely to change when support systems such as time off from teaching to attend professional development, feedback systems, continued follow-up and support from school administration are available. Dillon-Peterson (1986) observed that significant changes in instruction were likely to occur when introduced practiced and self critiqued in the context of the work situation and applied to real problems with appropriate outside support as needed. In the same vein, Bird and Little (1986) stated that teachers’ success with students depended on having adequate time, materials, facilities and equipment, and clear goals and policies. Students’ success and teacher improvement will require external resources, consistent district leadership, parents’ participation, and training and consultation time for teachers and teacher educators to work together in applying new options in the classroom.

In view of these observations, 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. According to Calderhead and Shorrock (1997) designing teacher professional development activities is a difficult task, educators are faced with difficult decisions, about the structure and content of the courses, about when relevant workshop material will be best introduced to students, and how students will be most appropriately prepared.

The workplace today, is constantly changing and bringing with it new technological innovations. Erber (1969) noted that, within a society encompassed by unprecedented technological change, it was imperative that industrial and technical teacher education programs focus attention on the development of the rational powers of the human being through the provision of technological problem solving activities that lead to high levels of intellectual exercise. In view of these observations, NCETE has proposed to refocus technology teacher preparation by seeking to develop teachers' capabilities as learners so that they assume leadership for their professional development activities, and facilitate teacher initiated change in program design, curricular choices, and student assessment, and other areas that will impact learning related to technology and engineering.

In light of this view, 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.

Petro said:

> We gave them a pretty structured assignment. They have to think about how they might implement this in one of their classrooms if they teach in multiple environments - and most of them do. Which class would they choose? What type of class would you choose? How would you introduce it? At what level would you introduce it? Structurally, how would you arrange it so that it fit into their program? Tomorrow afternoon, we're going to have an open discussion where each of them is going to give a presentation.

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 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 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.

Moko a middle school teacher attending the workshop at Eleven University pointed out that he liked the way instruction was presented in the workshop. He said, “Kicheko did not put everything in writing. Everything had a little bit of challenge packet to it, and I like the way it is. That’s the exact same way I will do it with students.” Letaa appreciated the power point lecture sessions and examples provided, hands-on activities, and demonstration of how the tools worked. He was happy that workshop facilitators did not assume that participants had working ideas of tools and equipment operations. He added, “They allowed us to either re-learn or to learn, and work the equipment without intimidation.” In contrast, Tembo objected facilitators reading from the power point slides. She recommended that more activities go with these lectures, activities that students will like doing and enjoy.

Benta 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. In this study workshop participants widely expressed their feelings toward the professional development workshop. Mesop exclaimed, “I have been exposed to some things which I can incorporate in the stuff that I already do. Abantu stated, "You learn by to learn by doing, and you know this workshop did that."

Harifa remarked:

> It's important to have hands-on component. I believe it's important for my students to have hands-on component in technology classes. If we're talking about improving my instruction for my students, then I would expect the workshop to have strong hands-on component and, this one did.

Hansman and Wilson (2002) pointed out that learners through their relationship with others and the context in which they are situated own their knowledge and have power over their learning. According to Letaa a middle school teacher, professional development opportunities provided such an experience to technology education teachers. It provided an opportunity to share teaching experiences, fellowship, collaborate and network. In view of this observation, it can be argued that professional development for technology education teachers should be designed to provide an environment where participants can have control over their learning experiences as they relate to each other.

When asked to share their visions for the workshop, Petro, referred to a drawing that illustrated a five year plan they had formulated for developing engineering analysis and design skills in technology teachers, and strengthening their mathematics, science knowledge, and skills. He posited that professional development should be designed to produce a domino effect he said, "By the time we get here, [refers to drawing] we shall have more seasoned people giving advice to people who are taking this for the first time, it will rub off eventually." Barno shared the same sentiments but his goal was different. His vision was to enroll freshmen from high school who had been exposed to engineering concepts and by the time they were ready to start teaching, hopefully he could pair them up with workshop participants to reemphasize engineering design in technology education. He believed this will change how we prepare technology education teachers.

The participants of this study offered different suggestions when asked to state one thing they would change in the workshop to meet their goals. Mesop retorted, “The math. That's what I would change. Change it so that they don't tell people it is not a math class.” I quickly replied, “But, engineering is math” to which Mesop responded, “Yeah, I know, but engineering is building also, I would be looking for more hands-on activities.” Moko stated, “Have other facilitators who need to teach instruct mini lessons demonstrating their expertise.” Ludiga and Letaa called for a greater variety of projects that showed a link between technology education and engineering design. Thande argued that it would make more sense to include more middle grade teacher who will develop and teach foundational courses.

In this study, professional development for technology education teachers can be viewed to be a series of specific activities that are conducted and undertaken by practicing teachers to enhance and update already acquired skills, gain new knowledge that will impact their teaching believes as well as that of their students with regard to new developments in the field and technological advancements at the workplace. 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. Additionally planners should formulate criteria to select individuals who attend and participate in the workshops.

Professional Development Workshop Activities for the Classroom

Erber (1969) argued that emphasis must be given to the development of conceptual skills through the provision of problematic situations that challenge the student's apprehension, imagination and ingenuity in his interaction with tools, machines, instruments, systems, materials and processes. Conceptual skills must be seen as prime requisites for effecting rational action that leads to productive and meaningful application of knowledge and techniques. These skills are judicial, creative, and experimental problem-solving activities of industrial and technical teacher education.

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. Brown, et al. (1989) further postulated that activity shapes students skills and provides experiences which are important in understanding concepts. They stated that representations arising out of activity cannot easily be replaced by descriptions. It can therefore be assumed that that situations might be said to co-produce knowledge through activity.

Staten (2004) posited that learning activities should be designed to elicit a state of flow in students. According to Staten the term "flow" implies a state in which people are so involved in an activity that nothing else seems to matter. They are so engrossed in what they are doing and are totally unaware of their surrounding as they enjoy and have fun completing the task at hand.

In other words these activities should be looked at, as tools of learning. According to Wilson and Cole (1991) such activities should be ordered from simple or easy to complex or difficult, and tasks designed to be administered early in the course should make use of skills that are components of later tasks.

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.

Kicheko stated that instruction should be designed in such a way that present learning capitalizes on students previous understandings. Brown, et al. (1989) stated that perceptions resulting from solving problems based on previous understandings are a central feature in both learning and activity. In other words, what they perceive may contribute to how they act and learn. Different activities produce different indexicalized representation and not universal ones. It then follows that the activity that led to those representation plays a central role in learning Knowledge is then embed in the context in which it arises and is used. The embedding circumstances provide essential parts of its structure and meaning (Brown, et al., 1989). In this study, workshop activities and instructions were designed to take control of the complexity of assigned tasks as participants recalled similar situations while they solved presented challenges.

All the facilitators pointed out that they encouraged participants to envision the final product as a team before attempting to produce. Wilson and Cole (1991) referred to this strategy as global before local skills. This approach helps learners acquire a mental model of the problem space at very early stages of learning. Learners are able to understand the goals of the activity and the way various ideas and concepts may relate to the problem's solution. Petro expressed it this way, "Having a set of expectations, a clear goal of where you're going, and what the product is going to look like, so you're working backwards." Felder (1993) argued that global teaching provides students with an opportunity to see how the material being presented relates to their prior knowledge and experience. Felder further advocated that teachers should demonstrate the logical flow of individual course topics, but also point out connections between the current material and other relevant material in the same course, in other courses in the same discipline, in other disciplines, and in everyday experience.

Perkins and Salomon (1992) posited that situating problems in a context was a pattern of learning that fostered transfer; students learn a body of content through tackling problems that demand use of the content. In view of this observation professional development activities and instruction designed to be infused into the K-12 curriculum should be designed to intrinsically motivate individuals by offering instructional activities that are sequentially organized, promote a state flow and lead to transfer of knowledge and skills to similar contexts..

In this study, participants expressed different views with regard to the design challenge and its transferability to the classroom situation. Harifa said, "I couldn't take that to my classroom because of time constraints. Besides, I have to water it down." Thande exclaimed, "I think that's they should have related it to what we are doing in the classroom." Moko stated, "I like the hands-on. I think that's what most students will enjoy." To this end, Limpo a workshop facilitator called for flexibility while staying true to the spirit of engineering when developing engineering design challenges.

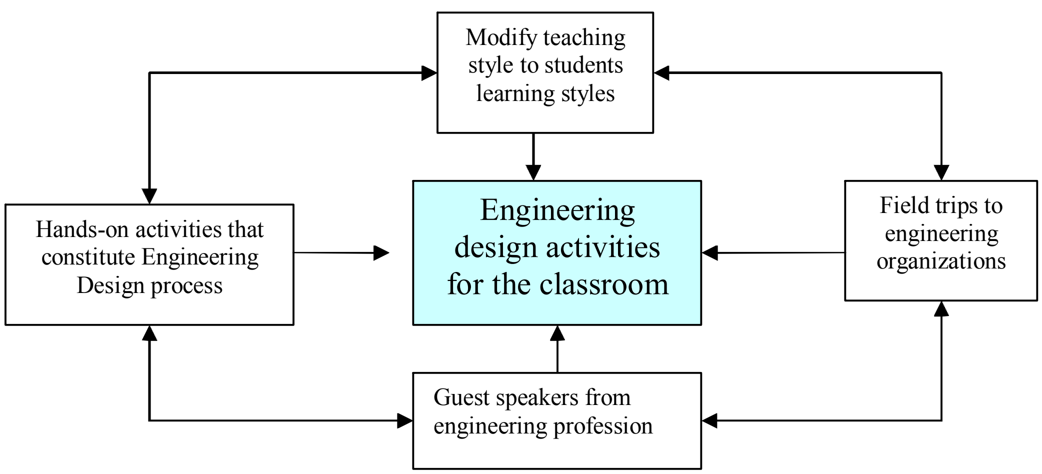
This is what he said:

> One thing I have learnt is that you cannot write one design challenge that fits everybody you have to be flexible. I have tried to build that in our challenge and tried to make it clear to teachers as we talk to them. I have said hey if you want to take this area and expand it some more, if it fits with what you are doing in your curriculum go do it if we are talking about this and you are not comfortable with it and does not fit with your students then minimize it. Expand and contract the parts that you want to do and you have to remain flexible but remain to the core of engineering design concepts. It's really up to them and I have provided them with background materials, resources, and publications.

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).

Hitch and Youatt (1995) posited that learning styles influence how a learner perceives and gathers information, sorts it, and makes decisions. On the other hand, Felder (1993) stated that it was not imperative to determine each student's learning style and then teach to it exclusively but seek to address each side of each learning style dimension occasionally. He posited that if such a balance could be achieved, students would then be taught in a manner that sometimes matches their learning styles, thereby promoting effective learning and positive attitudes toward the subject. In the same vein, Hitch and Youatt (1995) stated that instructors needed to balance instructional plans by selecting strategies and resources that cater to a variety if learning styles. This implied moving beyond only those with which the instructor was comfortable to include the range of activities that met the learning styles needs of students. Figure 9 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 9. Elements that play a role in successive implementation of engineering design activities in the classroom.



Expertise

Professional development has evolved from a focus on individual growth, to a fostering of organizational growth and now to a more, systemic, integrated perspective aimed to enhance the knowledge and skills of teachers through presentations, coursework, and workshops. The focus being to bring expertise to teachers in order to improve their classroom work with students (Sparks & Loucks- Horsley, 1989).

Detterman (1993) stated that people who know a lot about something are experts because of the specific information they have learned. According to Benner (1984) expertise develops when a novice teacher tests and refines propositions, hypotheses, and principle-based expectations in actual practice situations. Hansman and Wilson (2002) stated that viewing learning and knowledge construction from a practical perspective substantiates the knowledge of workshop participants elevating them to experts of their own knowing. In other words, learners develop their own understanding of the practical perspective surrounding their learning experiences as they become authorities of their learning. In view of these observations, Duffy (2005) asserted that when developing teachers; teachers should be encouraged to make their own decisions and take charge of situations they may encounter in their classrooms. In other words, the teacher should be encouraged to develop a vision that will count and not the expert's vision.

To infuse engineering aspects into the K-12 curriculum NCETE has proposed to prepare a pool of highly skilled teachers who will accept pre-service technology teachers into their classrooms and mentor the next generation of technology/engineering teachers. In other words NCETE seeks to develop teachers' expertise with regard to instructional decision making focusing on the analytical nature of design and problem solving needed to deliver technological as well as engineering concepts. To this end, it was noted that, engineering design facilitators in this study all held doctorate degrees with vast ranges of experiences in teacher education. At Eleven University, Letaa and Thande, reported that the professors demonstrated expertise throughout the workshop. Letaa said:

> Enough lecture to inform us and not bore us. Excellent examples and hands-on activities. Showing us how these tools work and not making any assumptions that we know how to do this and then allowing us to either re-learn or to learn.

Thande commented, “I really enjoyed, the approach they used to introduce the math concept, I can use that with my middle school students.” On the other hand, Moko gave a different opinion, he believed the knowledge base would move and flow more if all the experts were allotted equal time slots to teach, this is what he said, “I think it should have been less of Kicheko and more of the experts. When I say the experts I mean the expert in engineering, in math or engineering and not predominantly one instructor.”

The inclusion of an engineering faculty members as well as math professors and presentation of engineering design challenges in a contextual manner illustrated the level of commitment toward preparing workshop participants to develop some level of expertise. Limpo pointed out the presence of guest speakers who gave a talk about civil, electrical and mechanical engineering profession and specifically the engineering design process within their professions. He remarked, “The mechanical engineering person is a professor with extensive background in practice and the civil engineers, we actually had two speakers come in and they are from practice.”

Workshop participants expressed similar sentiments toward guest speakers. Visupu exclaimed, “They brought in a variety of people to explain things instead of just having one person teach. Somebody who is an expert on this talked about that.” Mesop said, “I liked how all of them had a variety of ways to pass knowledge, one person did power point the other one gave a good lecture with hand outs.” Mitaro, Abantu, and Benta pointed out the field trip they had taken earlier in the workshop were insightful.

Studies show that teacher expertise and knowledge of subject matter are important factors in student achievement (National Commission on Teaching & America's Future, 1996). Hansman and Wilson (2002) posited that learners can be helped to master more challenging content if teachers were experts in the subject matter being taught. Thus, educators must know more about the foundations of subject areas, must understand how students think as well as what they know in order to create experiences that produce learning. Benner (1984) noted that experience was a requisite for expertise and was the refinement of preconceived notions and theory through encounters with many actual practical situations that add nuances of differences to theory.

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. Benner (1984) posited that expertise depended on meaningful engagement in the situation. In this study, it was noted that teacher educators developed practical assignments that engaged and sought to prepare secondary teachers expertise in delivery of engineering design aspects. These challenges were practical meaningful problem solving activities that would build teachers' experiences and knowledge base of engineering practices as they relate to technology education.

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 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.

In this study, secondary teachers were exposed to engineering design aspects and expected to acquire some expertise in engineering design related issues in the context of technology education. Over a period of time this knowledge will become part of these teachers teaching practices and they will be expected to implement these aspects into their classrooms.

Meaning-Making

Fogarty (1994) posited that constructivists view learning as the process individuals experience as they take in new information and make sense of that information. By creating meaning, they are acquiring new information. According to Wenger (1998) meaning is negotiated. It does not appear from a void, nor is it the reflexive result of some procedure or routine. Once negotiated, this meaning has both a historical past and a dynamic future. In view of this observation, cognitive scientists argue that we can remember very few totally separate items at once, and all learning is a process of somehow associating new information with old. (National Commission on Teaching & America's Future, 1996).

At the very core of teaching is the task of helping students make connections between what they already understand and the new concepts, information, or skills that we want them to learn. In this sense meaning is in a constant state of negotiation in the lived experience of an individual and the environment in which they operate. Wenger (1998, p. 54) stated that meaning was both contextual and distinctive, “Meaning exists neither in us, nor in the world, but in the dynamic relation of living in the world.”

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 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.” Schell and Schell posited that creating new mental frameworks occurred naturally as the learner is challenged to dig deeper. They posited that this learning opportunity encourages learners to add to their existing mental frameworks on the topic; encouraging creation of meaning of appropriate choices for varying conditions in real or simulated contexts and setting. To this end, workshop participants stated that they negotiated their thoughts and made meaning of opinions presented in their teamwork activities to solve design challenge presented.

Additionally, workshop facilitators presented information to participants in a way that promoted meaning making to enable transfer of engineering design concepts to K-12 classroom settings. Visupu stated:

> The way they have been teaching us about engineering design they have presented activities, one was about team building and we used Lego, I won't go back and use Lego with my kids but I will take something that I already do with them and incorporate the concepts into that activity.

According to Haskell (2001), transfer of learning was the foundation of learning, thinking and problem solving. He posited that transfer of learning involved use of past learning when learning something new and the application of that learning to both similar and new situations. Haskell argued that we constantly transfer and make meaning of our previous learning and experiences in order to more quickly and efficiently learn a new skill. In the same vein, Schell and Schell (in press) posited that learning transfer was dependent on how the learner interprets the setting and the nature of the learning context.

When asked to explain the design challenge he was working on and how he would incorporate it into his classroom, Abantu expressed his meaning making of the situation as portrayed in the conversation below

> **P:** I had you talk about an engineering design challenge that you are working on can you please elaborate on that?
> **A:** We are taking a building, well how about if I tell you how I will present it to my students?
> **P:** That will be good.
> **A:** I will tell my students I am thinking about building a building next to a fault the San Andreas fault, because its a location nearby I am going to build the building and I need you because you are an expert on building structures.

From the above conversation it can be assumed that Abantu has already made meaning of the design challenge and was ready to describe how he would present the concepts to his students. Ludiga, a retired software engineer presented a set of rhetorical questions, expressing his inquisitive meaning making process, he posited, “What are the engineering concepts they are trying to teach? Are they trying to teach us how to sketch out a raw design and implement.”

Workshop participants’ statements with regard to meaning making elicit that, professional development workshop activities provide individuals with opportunities to experience and see how they can improve on their teaching practices. It can be argued that such workshops help stimulate ideas, add variety, and creativity in lesson planning and administration as participants dig deeper in to their mental structures to create meaning of presented design challenges.

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.

Popham (2004) defined assessment as a broad descriptor of the kinds of educational measurement that teachers use. He further described assessment as a formal attempt to determine students' status with respect to educational variables of interest. Variables are what teachers are interested in assessing. For example, if teachers are interested in how confident students are regarding their own sketches, then students' sketches would be a variable of interest. In this study, the variable of interest as described by the facilitators was infusion of engineering concepts into the K-12 curriculum. In light of this view, workshop facilitators employed different strategies to meet this goal.

It was noted that assessment took place during the third segment of the workshop, which happened to be during the academic year. This was strategically planned so that workshop facilitators could visit workshop participants' schools to observe implementation of engineering concepts in the classrooms. At Eleven University, as part of assessment procedures, Kicheko said that they asked participants' to keep a portfolio (engineering design notebook), that included notes they had given them through the spring, book chapters and articles that had explanations of engineering design concepts, and documentation of their thoughts on what their group could have done better upon completion of the design challenge. In other words, this portfolio was a reflection of participants' workshop experience. He further reported that, to assess teachers' performance of workshop activities, they used a rubric (appendix D). This rubric was set up in a way that participants got a better rating if they established criteria and compared the probable solution to those criteria. Kicheko posited that he encouraged participants' to conduct a reflective analysis activity. Additionally, participants' were required to complete a survey that sought to evaluate the professional development.

This is what Kicheko said:

> We make several trips to participants/schools to observe them teach. We survey them on their anxieties about implementation and make a schedule of their predictions about when they going to implement engineering design in to their curriculums. This year we would

> like to collect a video tape, portfolios, and standardized technology educational test scores.

At Twelve University, workshop participants' and facilitators' converged at what they called the "host" school. The "host" school was the home institution of the participant who had successfully implemented engineering design activities into their program and had the most positive experiences to share.

Petro stated:

> This accomplishes a couple of things. They've been meeting in this room, at Twelve University for eleven times. Quite frankly, they've had enough of this institution and being in this room. So, we want to get them into a high school setting as a cohort. It also gives us an opportunity to highlight a program that's doing really well, so they can get the most of good ideas and the right way to do it. We also have a meeting while we're there.

Limpo and Petro reported that they teamed up year one's participants with year two's participants' for advice and support. They then met at the host school for a round table discussion where they talked about implementation challenges, what worked, what did not work, and what would they do differently. Limpo posited that this was a real important part of assessment. In addition, he stated that during the spring and summer workshops they would conduct assessment, by asking participants' to complete a survey that sought to find; what they liked best, what they liked least, if they had any points that they would like clarified, and what they would differently if they were conducting the workshop.

Limpo remarked:

> Now that these groups have had their professional development we will get feedback from them. Whatever their recommendations are we will weigh them and put them into use for the third years' participants.

Workshop facilitators in this study outlined various ways they assess workshop goals and objectives. Participants' portfolios in the form of project documentation and reflective analysis, observation visits and discussions that elicited the importance of a community of practice as an approach to improving instructions, presentations that highlighted participants' implementation plans of engineering design activities in their curriculums, and a rubric that identified suitable design outcomes based on pre determined criteria were revealed as important elements in instituting ongoing professional development activities in engineering design in the context of technology education. This observation concurs with Schell (2001) arguments that contextual teaching employs assessment that is ongoing, derived from multiple sources and blends into instructional activities.

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.

Summary

Fifteen interviews, video footage, observation, and artifacts yielded several hundred pages of text from which individual case and cross–case analysis produced the preceding results and discussion. Workshop participants and facilitators opinions were presented. Additionally, professional development emerged as a core theme. The following components; (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, were viewed to play an integral role for engineering design professional development activities in the context of technology education to be successfully administered. In Chapter Six, I examine the implications for practice.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS FOR PRACTICE

This qualitative case study was designed to describe a process by which technology education teachers can be prepared to teach engineering design concepts in the context of 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?

In response to these questions, a set of interrelated findings from workshop facilitators and participants, and emergent themes and commonalities were inductively derived from the data using the constant comparative method of analysis. This chapter is organized to first summarize the research study, the research problem, purpose, and research questions. Next, a discussion of how the findings address the problem and purpose of the study are presented. Conclusions reached at the end of the study as they relate to the current literature and implications for practice and suggestions for conducting future research are presented.

Summary of Research Study

This study emanated from a funded project that I conducted (June-Dec 2005) to identify critical features of engineering design that could be incorporated into technology education learning activities. Having successfully conducted this study and submitted a technical report as well as an article for publication highlighting key features of engineering design aspects in technology education, the findings impelled me to conduct a study that looked at how these features were being incorporated in design challenges.

The dissertation study sought to investigate the perceptions of secondary technology teachers toward professional development workshops designed to help them gain skills and knowledge that would enable them incorporate elements of engineering design into secondary technology education curriculum. I conducted a multisite case study that was informed by 15 interviews, video footage, observation, and artifacts on teacher educators and secondary school technology education teachers' experiences of engineering design professional development activities as applied to technology education.

In September of 2005, I contacted NCETE via email (Appendix B) to inform them of my intention to conduct a research study in their Technology Teacher education preparation centers. These centers were comprised of five universities located in the United States of America. The response was positive and I contacted each center in January of 2006, and later met with facilitators from each university in May of 2006. Upon our meeting in May of 2006, I learned that workshop schedules at Eleven University and Twelve University worked well with my data collection timeline. I applied for human subjects clearance from each university, after workshop facilitators from these two schools assured me of their support and willingness to participate in the study.

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. I divided the transcripts into two groups, workshop facilitators and workshop participants. 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).

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 3 at middle school.

Summary of Purpose, and Research Questions

Today, technology education curricula is posed with questions about future directions due to changes in the social, economic, political, and technological forces in every sector of our lives. Leask (2001) posited that these rapid changes illustrate the necessity for regular review of technology education curricula and a need to constantly upgrade teachers' knowledge and skills. Previous research has reported the challenges of continuously preparing career and technical education teachers (McCaslin & Parks, 2002; Lynch, 1990, 1997). Today, teachers' professional development opportunities are of low quality and they often have too few opportunities to improve their knowledge and skills (NCCTE, 2001).

Currently, the field of technology education stands at a critical juncture in its history. Clark (1989) postulated that technology education is in a crisis caused largely by the increasing changes that are occurring within society and technology. Israel (1992) identified the importance of developing a multifaceted curriculum that depicts the versatile nature and scope of technology education. Lewis (1999) stated that the relationship of technology education to other subjects in the curriculum was a fruitful area of inquiry. He posited that it was imperative to find if integration with other subjects helped improve student learning of technological concepts and processes.

Scholars in the field of technology education have proposed that the field can benefit from looking at the experiences of other subjects that have held technological processes to be fundamental to their natures. This perspective places engineering as the professional field most closely associated with technology. To this end the National Center for Engineering and Technology Education (NCETE) proposed to prepare middle school and high school technology teachers to infuse engineering design, problem solving content, and analytical skills by conducting engineering design professional development activities. In light of this view, it is important for the field to find out the experiences of teacher educators, beginning teachers as well as those of practicing ones when attending engineering design professional development workshops in order to prepare programs that are appropriate for the full spectrum of participants.

I was interested in studying how NCETE centers are preparing high school technology teachers to infuse aspects on engineering design into technology education curriculum at the K-12 level. Additionally, I sought to find secondary technology teachers reflections with respect to content, delivery methods, strengths, and weaknesses of engineering design workshops at Eleven University and Twelve University. The findings of this study will enhance efforts to infuse engineering design as a focus for technology education.

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 is identified through professional development workshops administered by teacher educators' at two selected National Center for Engineering and Technology Education (NCETE) sites. This study proposes 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.

Specific objectives of the study were to (a) investigate the content, methodology and instructional practices of teacher educators facilitating engineering design workshops at selected NCETE sites, and (b) document secondary technology teachers' reflections concerning their experiences with respect to content, delivery methods, strengths, and weaknesses of engineering design professional development activities at two NCETE sites. Using convenience sampling (Patton, 2002) and data collection through interviews, observations, video footage and artifacts, I conducted a multisite case study that generated themes and patterns of teacher educators' and technology teachers' engineering design workshop experiences at two national center consortia universities: Eleven University and Twelve University.

Research questions

The following research questions guided my study:

1. How are the two sites similar or different?
2. What factors influence teacher educators' choice of content and instructional activities when conducting engineering design professional development workshops?
3. What theories of instruction and learning do teacher educators use to teach engineering design in professional development workshops? What influences teacher educators' choice of theories?
4. How do teacher educators conducting professional development workshops evaluate the effectiveness of the workshops in meeting stated objectives?
5. What are the reflections of secondary technology teachers' experiences with respect to content, delivery methods, strengths, and weaknesses of the engineering design workshops? What do secondary technology teachers say are the strengths and limitations of each program?
6. What would secondary technology teachers like to have changed in engineering design professional development workshops with regard to content and instructional activities? What are the reasons for the changes?
7. What implications for subsequent programs can be drawn from data collected at the two sites?

How Results Address the Research Questions and Purpose of the Study

The process of preparing technology education teachers to teach engineering design concepts in the context of technology education is elaborate and can be a longitudinal objective. In this study a key guiding question was, "How are secondary technology education teachers attending engineering design professional development workshops prepared to infuse engineering design aspects into the K-12 curriculum?" Additionally, the study sought to investigate the content, methodology and instructional practices of teacher educators facilitating engineering design workshops at selected NCETE sites, as well as document secondary technology teachers' reflections on their experiences with respect to content, delivery methods, strengths, and weaknesses of engineering design professional development activities at two NCETE sites.

To answer such a question and meet the stated objectives two NCETE sites that were involved in preparing teachers to infuse engineering design aspects into the K-12 curriculum were examined and participants interviewed. Video footage of workshop participants solving design challenges, interview data, and artifacts yielded 300 pages of data that lead to a deeper understanding of engineering design content professional development activities in the context of technology education. 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 I learned from this study:

a. Professional development has different definitions. Participants in this study pointed out that professional development was (a) a lifelong learning process geared toward improving performance skills and knowledge of individuals in a given field of practice (b) synonymous to inservice and considered as a way of providing teachers with new teaching tools, after they've entered the profession (c) learning what the state of practice or the state of art in the field was by keeping up to date through taking courses, attending seminars, and practicing engineering by conducting research, and (d) an opportunity to be taught how to be a better teacher and learn new things that enable them to make a better connection to what they were doing with their students. In light of these observations, professional development is a long-lasting, continuous life activity that can be described as a process that seeks to inculcate in teachers or individuals in a given profession, skills and knowledge that reflect changing times in the field and encourage them to change their mode of practice. Notably none of the participants based their definitions from referenced materials.

b. Project based learning is a powerful way to conduct engineering professional development workshop activities geared to help infusion of engineering aspects into technology education. Additionally, field educational trips help embed in students, learned skills and foster knowledge of real life work situations.

c. To meet stated objectives, professional development requires commitment from facilitators and participants as well. There needs to be a planning process that reflects on the professional development and beyond. The learning environment should be designed to accommodate intended workshop outcomes and related activities to be carried out during the course of the workshop. Workshop participants should feel welcomed and comfortable to attend and participate in this environment. When instituted and conducted as planned, professional development can help change teaching practices of target groups as evidenced by the reactions of workshop participants in this study.

d. 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. Problems and challenges are solved as individuals who share same experiences, goals, and vision are involved in constant negotiations. In this study, professional development activities presented teachers with an opportunity to share experiences, network, and solve common problems together as they strived to find a common ground among themselves and solve presented design challenge. In most instances the participants reported discussions among themselves as they conducted predictive analysis, brainstormed and optimized possible solutions to design challenge. This further presents and fosters meaningful learning among and within individuals. In other words, learning new material is enhanced as individuals who share similar goals negotiate experiences and work in teams to solve engineering design problems as they keep true to the spirit of engineering design principles.

e. 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.

f. Workshop facilitators should guide participants to finding solutions to design problems presented, through strategies like reflective analysis, global before local, sequencing, lectures etc. Such strategies elicit participants previously held beliefs. Participants' are therefore prompted to recall information stored in their funds of knowledge to solve current problems. In other words different teaching strategies can be incorporated to meet objectives of design problems and challenges presented to students.

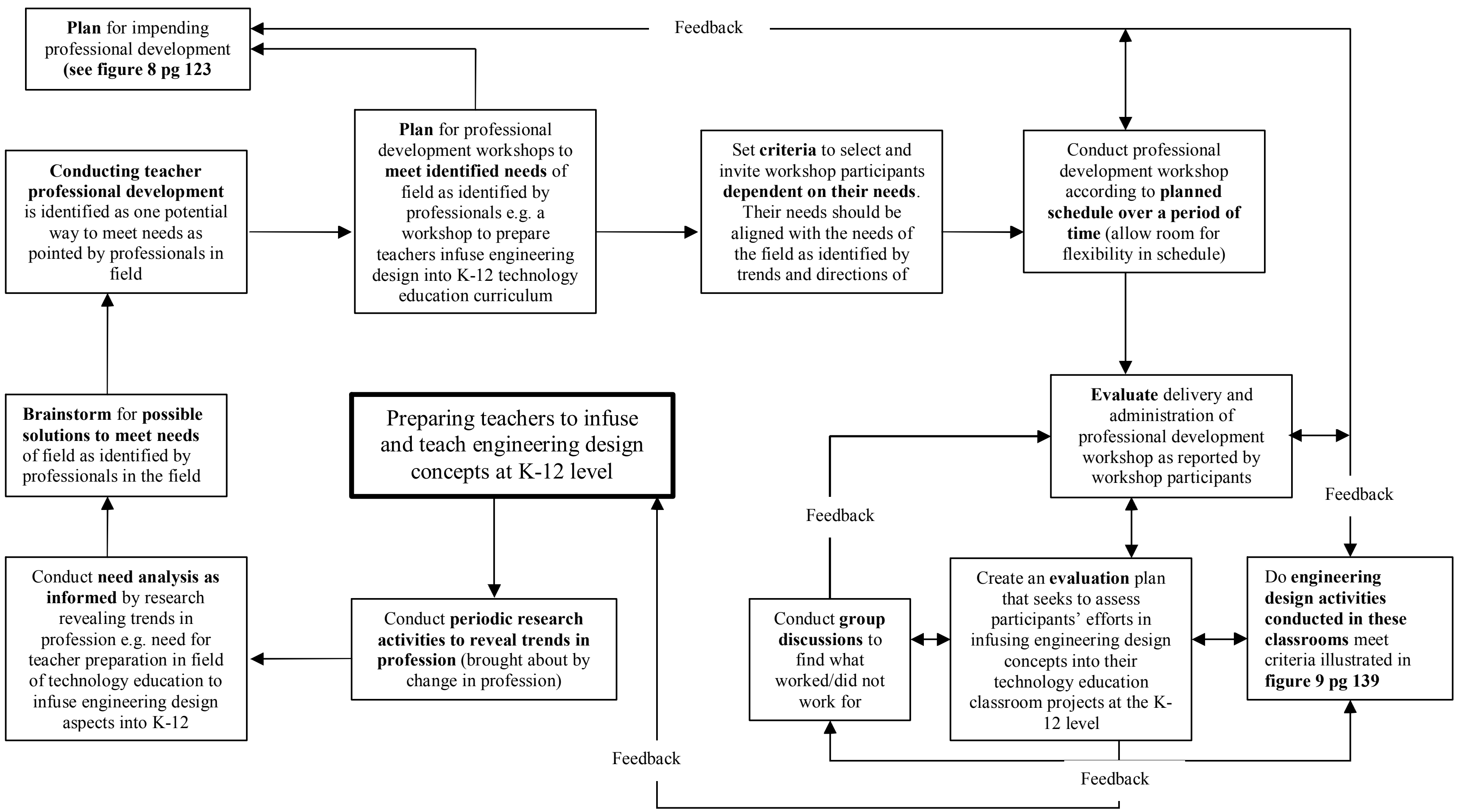
g. Professional development engineering design activities situated in a contextual environment may help students to be actively engaged and view learning as relevant to meaningful real world problems, learn from each other, and develop high order thinking and problem solving skills as evidenced by the comments of workshop participants in this study. Such activities can present students with a learning environment that is lively and self-motivating. In other words, situated learning environments help students stay on task as they develop skills and knowledge to solve presented challenges. Such experiences may help them transfer new acquired skills to similar situations when encountered in the future.

h. Individuals undertake professional development for various personal and professional needs depending on where they are in their careers. In this study, teachers highly appreciated, valued, and welcomed any form of professional development activities that are meaningful to their careers as well as students. In view of this observation, professional development activities should be developed to meet teachers at their point of need and should be geared to help improve learning directed to our students.

i. 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.

j. Figure 10 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.

Figure 10. 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.



How Results Address the Theoretical Frameworks Guiding this Study

Two theoretical frameworks, constructivism and communities of practice were combined to guide this study. Each framework contributed important perspectives from which to establish the design, analysis, and interpretation of data. Virtually all the workshop participants in this study reported to have recalled and applied previous held information to solve design problems presented during the workshop. Additionally, workshop facilitators pointed out reflective analysis as one of the key instructional strategies they used when conducting the workshop. These observations are in accordance with Brooks and Brooks (1999) who postulated that each of us make sense of our world by synthesizing new experiences into what we had previously understood. Further, this notion was espoused by Jarvis (1992) who pointed out that every experience, about which individuals reflect, is perceived through all the learning embedded in their funds of knowledge as a result of previous experiences. It can therefore be argued that participants in this study solved presented design challenges by reflecting on their previous experiences. Fosnot (1996) referred to this process as constructivism, which describes what knowing is and how one comes to know.

In this study, constructivism is evidenced by participants when they negotiate their previous experiences and thoughts to solve presented design challenges as well as through the reflective practices workshops facilitators' require them to undertake. It then follows that educators should strive to design instructions and learning environments that students make connections between current situations and their previous experiences. This findings are consistent with Detterman (1993) as well as Greeno, Moore and Smith (1993). Detterman posited that humans adapt and use previous experiences to advantage in new situations. In other words they transfer knowledge to new situations. In the same vein, Greeno, Moore and Smith

(1993) stated that, for students to make connections between concepts, instruction should be designed to influence the activity so that it includes attention to affordances that are invariant across changes in the situation and that will support successful interactions in a new environment. In view of these observations, hands-on activities and educational field trips that are meaningful and relevant to students' lives, should be applied to instruction geared to foster significant learning and teaching practices.

On the other hand, Wenger (1998) stated that communities of practice develop around things that matter to people. As a result, their practices reflect the members' own understanding of what is important. Wenger further posited that knowledge is created, shared, organized, revised and passed on within and among these communities. According to Barab and Duffy (1998) communities of practice refers to the process of social learning that occurs when people who have a common interest in some problem collaborate over an extended period in a contextualized environment to share ideas, find solutions, and build innovations. In light of this observation it can be argued that communities of practice is a group of people who construct an understanding of things they have in common, discuss and strive to solve each other's challenges by virtue of negotiating meaningful experiences. In this study, a group of individuals who shared common interests, that enhances instructional practices toward infusion of engineering design aspects in the context of technology education at the K-12 level participated in professional development workshops espousing the concept of communities of practice.

Nearly all participants in these workshops expressed a desire to improve their teaching practices as well as their students' skills and knowledge. They worked together to explore and solve design challenges presented, discussed a variety of issues they faced in their practice in addition to those they may face with implementation of engineering design in their technology education curriculum. Brown, et al. (1989) stated that teachers rarely had the opportunity to hear enough of what students thought about their practices. They argued that such information revealed misconceptions and in-effectives strategies confronting teachers' practices. Given this observations, the findings of this study reveal that communities of practice is an important concept that can enhance instructors' teaching practices as well as help a group of students to share, develop and acquire knowledge, and problem solving skills by solving educational challenges that spur an interest in them. Educators should encourage students to voice their interests and seek ways to develop learning experiences and materials that revolve around these interests. This observation mirrors cognitive apprenticeship as described by Brown, et al. (1989) who posited that cognitive apprenticeship methods try to enculturate students into authentic practices through activity and social interaction similar to craft apprenticeship. Such learning experiences help the flow of vital information among peers and can help break down important concrete tasks into simple manageable ones, leading to solving of challenges without each student having to master and remember everything.

Possible Implications for Professional Development Application

The findings of this study as well as reactions and perceptions of workshop participants and facilitators toward questions guiding this study resulted in several implications for engineering design professional development workshops for secondary technology teachers. These implications 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. 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. Such information is invaluable and will continually enhance teacher educators' efforts to prepare secondary technology teachers to infuse engineering design aspects into K-12 curriculum. To this end, teacher educators should more directly involve high school and middle school teachers, as well as administrators, policy makers, and students in the planning, administration, and conduct of professional development that seeks to change the curriculum and teacher practices.

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. Technology education teachers at the K-12 level need to develop design challenges that: (a) include field trips to engineering organizations, where students see and experience engineering practices in real world settings, (b) provide hands-on design challenge activities that require students to work in a team that exhibits community of practice attributes and employs the systematic process used in engineering to develop logical solutions, that is, in other words project based learning activities that seek to incorporate engineering design principles, (c) invite guest speakers from the engineering profession, and (d) enable teachers' use of a variety of instructional strategies that will facilitate infusion of engineering design aspects into technology education activities.

Future Research

The process of writing this dissertation study, conducting data analysis, member checks and meetings with colleagues and mentors who are experts in the field helped me reflect on my findings and gain more insight into teacher preparation practices and the ways in which these practices can be improved. Based on the findings of this study and my experiences in conducting the study, I see opportunities for future research in order to gain further insight into practices that can help incorporate engineering design into the K-12 curriculum. Specifically, I suggest the following research directions:

a. 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. Such a study could reveal more information on how to continually improve these workshops and integrate engineering design at the K-12 level. Further, a quantitative study that targets all workshop participants and their students should be conducted after the 5 year period designated by NCETE. Such a study could yield participants' attitudes towards engineering design as the focus of technology education.

Additionally it could also reveal information about the trends in the field of technology education with engineering design as the focus over this period of time.

b. Conduct follow-up study to find out how workshop participants implement engineering design aspects into their classroom activities. Such a study would yield information on the difficulties, challenges, strategies as well as benefits of incorporating engineering design into K-12 curriculum.

c. 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. Such a study may yield information that would help the field develop design challenges that are of interests to students, help teachers understand how students learn design principles and problem solving techniques, help teachers modify their practices to accommodate students' range of learning strategies when presented with design challenges.

Conclusion

This qualitative study has yielded important information that may lead to improving planning procedures for teacher educators, and individuals who conduct engineering design professional workshops, as well as invaluable information that may help policy makers, school administrators, secondary teachers and the general populace understand the importance of engineering design activities at the K-12 curriculum level.

A process for preparing teachers to infuse engineering design aspects was noted. Additionally the following components were found to play an integral role in the administration of professional development workshops geared toward infusing engineering design in the K-12 technology curriculum (a) planning, (b) communities of practice, (c) professional development administration and learning environment, (d) professional development for technology education teachers, (e) professional development activities for the classroom, (f) assessment, (g) expertise, and (h) meaning-making.

So what does this mean? 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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APPENDICES

APPENDIX A
INTERVIEW GUIDES

Conversational Interview Guide

(Teacher educator's semi structured interview)

As you know, I am interested in learning more about your beliefs and practices as you plan, conduct and implement professional engineering design workshops. I know that you are involved in teaching engineering design concepts and I am definitely interested in learning more about your perspectives on this issue. I appreciate your taking the time to talk with me about your experiences.

Before we get started, let me go over a few things about the interview;

- It will probably take about 40-50 minutes. Because I can't write fast enough, I would like to audio tape your responses.
- The questions that I will ask will be general so please feel free to expand on them however you would like.
- Your participation is completely voluntary, you can stop the interview at any time and you only have to answer the questions you want.

Do you have any questions before we start?

1. In your own words, please describe what a professional development workshop is? And what are some of the activities you conduct to ensure that such a workshop is a success?
2. What kind of content/activities do you teach in these workshops? What factors influence you to choose these activities?
3. What factors influence your choice of content and instructional activities when conducting engineering design professional development workshops?
4. What theories of instruction and learning do you use to teach engineering design in professional development workshops? What influences you to choose these theories?
5. Can you please explain how you assess workshop participants design challenges/activities?
6. How do you plan to continuously update and administer future professional development workshops?

Conversational Interview Guide

(Secondary technology teachers' semi structured interview)

As you know, I am interested in learning more about your beliefs and experiences with respect to content, delivery methods and strengths and weaknesses of this workshop. I am interested in learning more about your perspectives on this issue. I appreciate your taking the time to talk with me about your experiences.

Before we get started, let me go over a few things about the interview;

- It will probably take about 40-50 minutes. Because I can't write fast enough, I would like to audio tape your responses.
- The questions that I will ask will be general so please feel free to expand on them however you would like.
- Your participation is completely voluntary, you can stop the interview at any time and you only have to answer the questions you want.

Do you have any questions before we start?

1. What grades are you teaching now?
2. How many years have you taught technology education? Could you please elaborate on your program and design challenges that you perform with your students?
3. How were you educated to become a technology teacher? How did you come to participate in the engineering design workshops?
4. What do you like the most about the content, delivery methods and design challenges that you perform in this workshop? Do you think engineering design problem solving activities enhance your understanding of problem solving and design skills if yes please elaborate? If not, please explain some of the things you would like to be done to enhance your skills
5. How will this workshop influenced your design of technology education activities with engineering design as the focus?
6. What should workshop planners know and do for future participants?
7. If you were to change one thing about this workshop what would that be?

APPENDIX B

COVER LETTER TO NCETE WORKSHOP ADMINISTRATOR

Dear NCETE Workshop Administrator

My name is Paul Andeka Asunda, a doctoral student in the Department of Workforce Education, Leadership and Social Foundations at the University of Georgia. I am conducting a research study titled "Engineering Design Content and Participating Teacher Perceptions of NCETE Professional Development Workshops" under the supervision of Dr. Roger B. Hill, 209 River's Crossings, Athens Georgia at the University of Georgia.

This study seeks to measure the alignment of NCETE professional development workshops with the engineering design process and to investigate the perceptions and implementation plans of participating teachers. It is perceived that this study will help teacher educators in technology education reflect on best practices for preparing future and current technology education teachers. The study will also inform secondary teacher educators as they initiate changes in program design, curricular choices, student assessment, and other areas related to the success of technology education as a field.

The intent of this letter is to ask for your center participation in the study. A packet of survey materials and administration instructions in addition to a self-addressed stamped envelope will be provided for your centers convenience. You will be asked to administer the Engineering Design Rubric and Team Design Skills Growth Survey to your workshop participants as per the instructions attached to the instruments and mail them back to the researcher. The information collected will be for study purposes and will be shared with the NCETE centers upon completion of the study. Any information the researcher obtains about the study participants will be kept confidential and destroyed as soon as the study is completed.

If you have any questions concerning the research study, please contact me at 706.207.3005 or pasunda30@hotmail.com or Dr. Roger B. Hill at 706.542.4100 or rbhill@uga.edu. Thank you for considering this request. Please find attached sample survey instruments, and an abstract of proposed study.

Sincerely

Paul Andeka Asunda
Doctoral Student

APPENDIX C
RESEARCH CONSENT FORM

CONSENT FORM
(Faculty)

I, _________________________________, agree to participate in a dissertation study titled " A multisite case study of faculty and teacher perceptions of NCETE professional development workshops on engineering design content" conducted by Paul A. Asunda from the Department of Workforce Education, Leadership, and Social Foundations at the University of Georgia (706 542-1682) under the direction of Dr. Roger B. Hill, Department of Workforce Education, Leadership, and Social Foundations, University of Georgia (706 542-4100). I understand that my participation is voluntary. I can stop taking part without giving any reason, and without penalty. I can ask to have all of the information about me returned to me, removed from the research records, or destroyed.

The purpose of this study will be to describe a process of preparing technology education teachers to teach engineering design concepts in the context of technology education.

If I agree to take part in this study, I will be asked to answer the following questions:

1. In your own words, please describe what a professional development workshop is? And what are some of the activities you conduct to ensure that such a workshop is a success?
2. What kind of content/activities do you teach in these workshops? What factors influence you to choose these activities?
3. What factors influence your choice of content and instructional activities when conducting engineering design professional development workshops?
4. What theories of instruction and learning do you use to teach engineering design in professional development workshops? What influences you to choose these theories?
5. Can you please explain how you assess workshop participants design challenges/activities?
6. How do you plan to continuously update and administer future professional development workshops?

The interviews will probably take about 40-50 minutes, at a convenient location to both the interviewer and interviewee. My responses will be audio taped and destroyed 1 year after the study. My participation in this study will lead to information that will help scholars in the field of technology education address critical problems facing the profession. No discomforts, stresses, or risks are expected.

Any information collected about me will be kept confidential. An exception to confidentiality involves information revealed concerning suicide, homicide, or child abuse which must be reported as required by law or if the researcher is required to provide information by a judge. The investigator will answer any further questions about the research, now or during the course of the project (706-207-3005).

I understand that I am agreeing by my signature on this form to take part in this research project and understand that I will receive a signed copy of this consent form for my records.

_________________________	_______________________	__________
Name of Researcher	Signature	Date
_________________________	_______________________	__________
Name of Participant	Signature	Date

Please sign both copies, keep one and return one to the researcher.

Additional questions or problems regarding your rights as a research participant should be addressed to The Chair Person, Institutional Review Board, University of Georgia, 612 Boyd Graduate Studies Research Center, Bantu, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu

CONSENT FORM
(Secondary technology teachers)

I, _______________________________, agree to participate in a dissertation study titled " A multisite case study of faculty and teacher perceptions of NCETE professional development workshops on engineering design content" conducted by Paul A. Asunda from the Department of Workforce Education, Leadership, and Social Foundations at the University of Georgia (706 542-1682) under the direction of Dr. Roger B. Hill, Department of Workforce Education, Leadership, and Social Foundations, University of Georgia (706 542-4100). I understand that my participation is voluntary. I can stop taking part without giving any reason, and without penalty. I can ask to have all of the information about me returned to me, removed from the research records, or destroyed.

The purpose of this study will be to describe a process of preparing technology education teachers to teach engineering design concepts in the context of technology education.

If I agree to take part in this study, I will be asked to answer the following questions:

1. What grades are you teaching now?
2. How many years have you taught technology education? Could you please elaborate on your program and design challenges that you perform with your students?
3. How were you educated to become a technology teacher? How did you come to participate in the engineering design workshops?
4. What do you like the most about the content, delivery methods and design challenges that you perform in this workshop? Do you think engineering design problem solving activities enhance your understanding of problem solving and design skills if yes please elaborate? If not, please explain some of the things you would like to be done to enhance your skills
5. How will this workshop influenced your design of technology education activities with engineering design as the focus?
6. What should workshop planners know and do for future participants?
7. If you were to change one thing about this workshop what would that be?

The interviews will probably take about 40-50 minutes, at a convenient location to both the interviewer and interviewee. My responses will be audio taped and destroyed 1 year after the study. My participation in this study will lead to information that will help scholars in the field of technology education address critical problems facing the profession. No discomforts, stresses, or risks are expected.

Any information collected about me will be kept confidential. An exception to confidentiality involves information revealed concerning suicide, homicide, or child abuse which must be reported as required by law or if the researcher is required to provide information by a judge. The investigator will answer any further questions about the research, now or during the course of the project (706-207-3005).

I understand that I am agreeing by my signature on this form to take part in this research project and understand that I will receive a signed copy of this consent form for my records.

_______________________	_______________________	__________
Name of Researcher	Signature	Date
_______________________	_______________________	__________
Name of Participant	Signature	Date

Please sign both copies, keep one and return one to the researcher.

Additional questions or problems regarding your rights as a research participant should be addressed to The Chair Person, Institutional Review Board, University of Georgia, 612 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu

APPENDIX D
RUBRIC

Objectives	Below Standard	At Standard	Above Standard	Specific Comments
Followed the engineering design process.	There were steps left out that turned out to be important.	There is evidence that the process was followed.	There is explicit evidence that the process was followed.	
Used mathematics to optimize, predict, describe solutions.	Used some but not all math applications to describe the solution.	Used all math applications to describe and optimize the solution.	Used all math applications to describe, predict, and optimize the solution.	
Worked within constraints and limitations.	One or more special accommodation had to be made in the laboratory to get the solution to work.	No special accommodation had to be made in the laboratory to get the solution to work.	The solution worked as close to a real-life implementation as feasible in the laboratory and the decision matrix was used to analyze alternative solutions.	
Satisfied specifications and parameters.	None of the quantifiable specifications were met by the solution.	Some of the quantifiable specifications were met by the solution.	All of the quantifiable specifications were met by the solution.	
Applied understanding of automation and interfacing.	There is little evidence that the understanding of interfacing is represented in the solution.	It is evident that the understanding of interfacing is represented in the solution.	It is evident that the understanding of interfacing is represented in the solution and this is explicitly documented in the portfolio.	
Understands transportation as a system.	The student cannot describe the water system in the terms used to describe any transportation system.	The student can describe the water system in the terms used to describe any transportation system.	The student can describe the water system in the terms used to describe any transportation system, and this is evident in the portfolio.	
Understands communication as a system.	The student cannot describe the control system in the terms used to describe any communication system.	The student can describe the control system in the terms used to describe any communication system.	The student can describe the control system in the terms used to describe any communication system, and this is evident in the portfolio.	
Technology and society interact.	There is no portfolio evidence to show an understanding of the importance of water systems to society.	There is portfolio evidence to show an understanding of the importance of water systems to society.	There is portfolio evidence that the understanding of the interaction of technology and society is related to this specific problem.	
Fully documented the process in the portfolio.	The portfolio reflects the general engineering design process.	The portfolio provides evidence of understanding for the objectives stated above.	The portfolio documents the specific design process used to solve this problem.	
Comments:				