A PROFESSIONAL DEVELOPMENT STUDY OF TECHNOLOGY EDUCATION IN SECONDARY SCIENCE TEACHING IN BENIN: ISSUES OF TEACHER CHANGE AND SELF-EFFICACY BELIEFS

A dissertation submitted to the Kent State University College and Graduate School of Education, Health, and Human Services in partial fulfillment of the requirements for the degree of Doctor of philosophy

by

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This study has two purposes. The practical purpose of the study was to provide Benin middle school science teachers with an effective technology education professional development (TEPD) program which granted teachers with content knowledge in technology education (TE), PCK in TE, design hands-on models in TE, and design rubrics assessing students’ works. The research purpose of the study was to explore teachers’ TE content knowledge and PCK, changes in teachers’ self-efficacy beliefs in teaching the TE portion of the curriculum, and teachers’ perceptions of their TEPD experience after participating in the program.

Four sessions of the TEPD program were carried out with two groups of teachers \((N = 23 \& 28)\). A mixed methods research design was utilized to collect data. Pre-experimental one-group pretest-posttest research design was used to collect quantitative data. Two instruments, the technology education teacher self-efficacy beliefs instrument (TETEBI) and the TE Awareness instrument, were designed. The qualitative research design employed a case study with participating teachers’ after-session journals and after-session evaluation, classroom observations, teachers’ and students’ interviews.

Overall results of the study revealed that the TEPD program impacted positively participating teachers. Salient results indicated that (1) the TEPD program was effective;
(2) although quantitative analysis was inconclusive, through documents analysis, teachers’ self-efficacy beliefs were enhanced after participating in the program; (3) teachers did acquire TE content knowledge and PCK; (4) teachers were effectively teaching the TE lessons integrated in the science curriculum; and (5) teachers expressed positive perceptions about the program and acknowledged its soundness, relevancy and effectiveness. Other characteristics of effective PD have been founded such as trainers’ expertise and consideration of cultural and contextual issues of the trainees. Interpretations of the results led to ten educational implications that could improve TE teaching in secondary school settings in Benin, as well as in other developing countries with similar features. Finally, five recommendations were made for further investigations.
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CHAPTER I
INTRODUCTION

Background of the Study

In its broadest sense, technology is the process by which humans modify nature to meet their needs and wants (Pearson & Young, 2002). Indeed, technology is present in every domain of our society. Many countries are striving to establish technology in their school curricula as a subject in its own right (Layton, 1994; Lewis, 1991), particularly in science education. The literature underlines two significant trends in contemporary science education related to technology: educational technology and technology education. The former is related to the use of computers and related devices, whereas the latter pertains to the use of technology in the form of design and other activities that require students to work with materials to create devices that meet humans’ desired end (Association for Supervision and Curriculum Development, ASCD, 2002). Prime (2001) pointed out that “perhaps the most significant curriculum innovation of the last two decades has been the inclusion of technology education (TE) as a component of general education” (p. 1). In the United States, a variety of efforts has been undertaken to increase technology literacy. For example, the federal government, mainly through the National Science Foundation (NSF), has funded the development of a variety of technology-related curricula and instructional materials (Pearson & Young, 2002).

The importance for integrating TE as a curricular item has not escaped developing countries. Scholars relate children’s technology literacy to the development of the third
world countries. Lewis (2000) contends, “The school curriculum is a good place to begin, if poor countries are to create the institutional and social structures needed to reduce their dependence on imported technology” (p. 165), and children in these countries are to find space in the curriculum wherein to channel their inventive impulses.

Science and technology have reached a unique status worldwide today, such that no country can afford to treat them with levity (Ojo, 1996). Indeed, the status and power of a country in the world today depends on how successful that country has appropriated and used science and technology to find effective solutions to its socio-economic, cultural and political problems. On the one hand, “the developed countries have attained ‘technology sophistry’ by exploiting science and technology to create wealth, save human energy, provide technical services, and bring about great development resulting in very high standards of living for their people” (Ojo, 1996, p. 6). On the other hand, “if we exclude the East Asian tigers [mainly Japan and Taiwan], it is quite clear that developing countries [especially West Africans] are not bridging the scientific and technological gap with developed countries” (Archibugi & Pietrobelli, 2003, p. 870). Intergovernmental organizations such as UNESCO and the World Bank recommend that to eradicate poverty, developing countries must see technology not as something external to them, needing to be imported. Consequently, technology literacy is of paramount importance through teacher professional development (PD). Actually, in developing countries especially on the continent of Africa, it is well known that the existing teaching force is underqualified. One-third of existing teachers in sub-Saharan Africa, for example, are untrained (Leach, 2005). Indeed, “secondary schools in sub-Saharan Africa are beset with
many problems including ‘underqualified’ teachers, limited teaching practices focusing on memorization, and poor materials and facilities” (Sunal, 1998, p. xiv). On the other hand, recent research has indicated that locally based training, properly resourced and supported, can be a highly effective form of professional development (Zhao & Franck, 2003). Gordon and Yocke (1999) suggest that teaching and PD activities should address teachers’ needs for new curriculum development and the delivery approach to carry out this reform movement. Also, Fullan (2001) noted that in order to accomplish substantive school change we must address teachers’ beliefs, classroom approaches, and use of materials. Addressing these three aspects of teacher change requires thoughtful, patient PD and other supports. Consequently, an investigation on the effects of Benin middle school science teachers’ self-efficacy beliefs after participating in a technology education professional development (TEPD) is appropriate.

In Benin (West Africa), the national educational policy was designed to rehabilitate and improve both the quality and the equity of the education system, with an emphasis on pedagogy that stresses self-employment, creativity, independent thinking, and cognitive learning (Ministère de l’Education Nationale et de la Recherche Scientifique, 1990). Within this scope, TE has been integrated into the Nouveaux Programmes d’Etude [New Study Programs], particularly in the new science curriculum designed for the secondary school. In addition, the general orientation of these New Study Programs stipulates the necessity for sensitization and training of teachers for the mastery of the content knowledge, teaching approaches and strategies (Ministère des Enseignements Primaire et Secondaire, MEPS, 2003). Therefore, middle school physical
science teachers are trained to teach this subject matter when they attend the state
Superior Normal School located in the capital city Porto-Novo of Benin. However, these
teachers are not trained to teach the technology education/pre-engineering lessons that
have been integrated into the new science curriculum. Due to this lack of the content
knowledge and pedagogical content knowledge in TE, these middle school science
teachers are not teaching, or are reluctant to teach, the compulsory part of the science
curriculum. Consequently, it is important to investigate middle school science teachers’
content knowledge and pedagogical content knowledge, and teachers’ self-efficacy
beliefs to teaching TE after participating in a technology education-based PD.

The following sections that constitute the framework of this chapter include: (1)
the context of the study; (2) the rationale of the study; (3) the statement of problem; (4)
the theoretical framework of the design; (5) the purpose of the study; (6) the research
questions and hypotheses, (7) the definition of major terms, and (8) the significance of
the study.

Context\(^1\) of the Study

The context of the study provides some basic facts about the Republic of Benin,
an overview of the country’s educational system, a synopsis of Benin education system’s
different programs, and a concise outline of the general orientations of the physical
science and technology curriculum in Benin middle schools.

\(^1\) The information provided in this section originated from Benin official and educational documents
written in French. Even though the translation and statements have been double-checked and reviewed for
accuracy, the content of this section is exclusively the responsibility of the author and does not necessarily
represent the position of Benin officials and education system leaders.
Basic Facts about Benin Republic

Formerly known as the Republic of Dahomey prior to 1975, the Republic of Benin is a small West African country bordering Nigeria to the East, Niger and Burkina Faso to the North, Togo to the West and the Bight of Benin to the South (Atlantic Ocean). With an area of 112,622 square kilometers and a population estimated at 7.1 million people in 2005 (about 55% females and 45% males), the country is a multicultural society with 42 different ethnic groups and 55 national languages. Formerly a French colony which was declared independent on August 1, 1960, Benin’s official language of both government and schools is French, which is inherited from the colonization and spoken by a minority of the population. The country is divided into twelve provinces: Alibory, Atacora, Atlantique, Borgou, Collines, Couffo, Donga, Litoral, Mono, Ouémé, Plateau, and Zou.

Overview of Benin Education System

Benin’s education system is based on a high level of financial, administrative, and pedagogical centralization. The Ministry of Primary and Secondary Education determines the educational policy and the curriculum. Every aspect of schooling including aims, objectives, instruction, courses, hours, teacher training, textbooks, assessment, and the building of classrooms is state-controlled. Fundamentally, the educational system consists of a two-year kindergarten, a six-year elementary school, seven-year secondary school (a four-year junior secondary school or middle school and a three-year senior secondary school or high school), two- to five-year vocational and professional training centers and institutes, and two universities. At the end of the sixth year of elementary
school, a national standardized examination the *Certificat d’Etudes Primaires* [Certificate of Primary Studies] is designed to determine whether pupils can continue into middle schools. The secondary school is divided into two cycles: one lower cycle of four years called *Premier Cycle* or first cycle (middle school) and an upper cycle of three years called *Second Cycle* (high school). The first four years prepare students to take an examination called *Brevet Elementaire du Premier Cycle* (*B.E.P.C.*). The second cycle of three years prepares students for the *Baccalaureat* examination, the most important benchmark and the diploma needed to enter higher education. The country’s two institutions of higher learning are the University of Abomey-Calavy (founded in 1970) and the University of Parakou (founded in 2001). Some professional courses are not offered in these universities. So, students, teachers, and scholars are sent abroad to acquire needed knowledge and expertise for the development of the country.

**Overview of Benin Education System Programs**

Western education was introduced into Benin by missionaries in the 1860s in the southern coastal areas and in the interior around 1900 (Kurian, 1988). From the colonial period to date, the Republic of Benin has experimented with several educational reforms characterized by different types of programs: a) program by contents from the colonial period to 1975, b) program by objectives known as *Programme National d’Edification de l’Ecole Nouvelle* or simply “New School” (MEN, 1983) from 1975 to 1982, c) from 1982 to 1990, return to program by content known as *Programme Officiel* [Official program], d) program by objectives called *Programmes Intermédiaires* [Intermediate Programs] from 1991 to 1994, e) from 1994 to 2002, again program by objectives called *Nouveaux*
Programme d’Etude [New Study Programs] experimented in some pilot schools and expanded to elementary schools nationwide in 1999, and f) from 2002 to date, the updated New Study Programs – competency-based programs – have been expanded from elementary school to high schools nationwide. The colonial influence has remained in the education system (Kurian, 1988), even though attempts have been made to “adapt the curriculum to national needs and to locally produce textbooks and teaching materials” (Urch, 1992, p. 37).

Program by Contents (Pre-1975, 1982-1990)

This program consists of a listing of topics and titles of lessons to be taught, and relies heavily on students’ rote memorization. The teacher’s role is to expound the content of the different topics. The advantages of this program lie in the fact that the program is comprehensible and easy to be enacted. The program’s disadvantages include vagueness in the teaching strategies, multiple interpretations of the themes, elimination by the teachers of certain topics in case of doubt or uncertain understanding, and instruction and assessment hardly aligned.


This program encompasses a clear definition of the objectives, the teaching/learning activities, and the planning of the diverse tasks. The program is easy to carry out and the interpretation of each theme is unequivocal because the teacher is orientated within the teaching process. Its disadvantages reside on its lack of coherence and synergy between the subject matters and the relevance of knowledge, fragmented knowledge, and lack of the student’s reflective behaviors for a quicker mobilization of
information while solving problems, even though having the needed knowledge background.

**Competency-based Program (2002-Present)**

This is a student-centered program allowing the child to mobilize all the necessary competencies to solve scholastically and socially constructed problems. It has a direct relationship between the subject matters and the relevance of knowledge, systemic and continuous learning, endowing students the necessary way of thinking geared toward solving problems. In Benin, competency-based program is today subjected to many polemics because of its misunderstanding by the public. Indeed, most of students’ parents are unenthusiastic regarding the way the competency-based curriculum is implemented in schools.

**The New Study Programs in Benin Middle Schools**

The *New Study Programs* are a competency-based curriculum started in Benin middle schools in 2001. The implementation process went through two stages: experimentation in 90 pilot schools countrywide and expansion to all schools starting in October 2005. In *Science Physique, Chimie et Technologie* [physical science, chemistry and technology], various activities were conducted during the experimentation phase: training of curriculum specialists; design of the experimental version of the sixth grade to ninth grade curriculum; elaboration of documents such as teaching guides, activities books; training of pedagogic advisors and teachers; follow-up programs for evaluation; production of teaching materials and student assessment instruments; and evaluation of the experimentation of the *New Study Programs*. The expansion phase was comprised of
the production of the revised *New Study Programs* and teaching guides, the revision and improvement of the *New Study Programs* and teaching guides.

**Goals of the New Study Programs**

Because of the importance of science education in the development of a country with regard to current technological advancements and the challenges of the 3rd millennium, Benin educational leaders stressed the urgency to endow the educational system with a program integrating TE as a component of physics and chemistry programs, emphasizing socio-constructivist pedagogy, problem-solving, and inquiry-related activities. On the one hand, the political orientation of the *New Study Programs* emphasizes the cultivation of excellence from which intellectual, cultural, and moral values were to emerge (MENRS, 1990). On the other hand, these programs contribute to form a technologically competent and balanced citizen, to educate a citizen for lifelong performance, critical thinking, open-mindedness, inquiry orientation, self-employment, and for effective contribution for the development of the country. The student will no longer be subjected to rote memorization. Indeed, globalization and internationalization of curriculum studies allow educational and international experts to bring new ideas and support curriculum reform initiatives that emphasize the development of life skills and constructivist and/or cognitive learning theories in developing countries. The focus will be to develop students’ intelligence, creativity, and adaptability to new situations. Physics, chemistry and technology can enormously contribute to these goals, because they deal with natural phenomena and the observed world. In fact, science focuses on the study of general properties, the constitution and the transformation of different objects;
and also establishes the laws related to the natural phenomena; while technology deals
with tools and materials, their use, their repair, and their production.

Acting on the concrete, the student learns to solve problems of his environment by
referring to models and/or to appropriate strategies. In addition, throughout the middle
school, the pupil must progressively be able to:

- exploit available information to solve a situation-problem;
- exercise his critical and creative thoughts;
- manage his studies for an assignment to be completed;
- work in collaboration and show ethical sense;
- communicate in a specific and appropriate manner;
- frame an explanation of a fact or a phenomenon of his natural or constructed
  environment by implementing appropriate modes of reasoning in physical science
  and in technology;
- exploit physical science and technological procedure in the fabrication, use, and
  repair of technological objects;
- appreciate the contribution of physical sciences and technology in the human
  being’s life; stress his\(^2\) personal and cultural identity in the world in constant
  evolution;
- act individually and collectively in mutual respect and with open-mindedness; and

\(^2\) For speaking convenience, the researcher will be using the generic masculine third person singular. That
does not carry any gender discrimination.
Physics, Chemistry and Technology Education

Benin’s social and economic development requires citizens with scientific training in which physics, chemistry and technology subject matter is of paramount importance. Not only must the education system be built on the basis of professional competencies, but also on the basis of congruence between a scientific education and realistic expectations. Similar to other programs, physics, chemistry and technology education focuses on the development of the student’s competencies. The physics, chemistry and technology education curriculum is intended to help students develop observation skills, curiosity, and critical thinking through selected and appropriate learning situations (Institut National pour la Formation et la Recherche en Education, INFRE & Direction de l’Enseignement Primaire, DEP, 1999).

Learning Cycle Approach

The learning cycle approach (Karplus & Their, 1967) in the New Study Programs in physics, chemistry and technology is principally developed through problem-solving and project designs. The three phases characterizing the approach include the introductory phase, the concept construction phase, and the review and projection phase. These phases constitute the basis of the learning process universally utilized in competency-based programs.

The introductory phase puts the learner into a situation. This phase is conceived of as a pretest providing teachers with students’ preconceptions, misconceptions, and
prerequisite knowledge. All the activities are student-centered; the learner will start from a common life situation-problem correlated to the competences to be developed.

The “Réalisation” or concept construction phase (also called the phase of information treatment, of exchanges and synthesis) is student-centered and teacher-directed, and deals with pertinent and coherent activities proposed to the student. He will construct new knowledge from these learning activities. It is recommended that students work individually, in small groups, or collectively. The teacher will organize a collective learning situation where each individual or team reports its results and discusses the results of the other learning teams. During this phase, the teacher introduces new terms and appropriate vocabulary to label, describe, and explain objects, events, and concepts.

The “Retour et Projection” (review and projection) or extension stage comprises a review phase, a formative evaluation phase, a consolidation or enrichment phase, and an extension phase. At the end of the learning process, the teacher suggests an assessment activity doable in a relatively short time.

**Pedagogical Process**

The pedagogical process comprises the different methods used by the teacher to manage a class activity and to guide the student within his learning process. These methods are the coherent ways utilized by the teacher to help the student learn and to better master the learning object. The pedagogical process also includes relationships between teacher-student and student-student as well. The teacher’s actions in the classroom consist of:

- becoming aware of the students’ prior knowledge regarding the learning topic;
• taking into account their prior conceptions and misconceptions of the subject;
• facilitating the learning environment (material, group, human resource);
• proposing learning activities;
• providing clear and precise guidance for proposed activities;
• facilitating student’s knowledge building;
• encouraging students to connect prior and new knowledge;
• supporting exchanges between different small groups, and managing group work;
  assisting with the review and projection phase; and
• constantly performing formative evaluations.

The Competencies

Competency is “the combination of skills, abilities, and knowledge needed to perform a specific task” (National Center for Education Statistics [NCES], 2002). Competency is the knowledge, skills, and attitudes that enable one to effectively perform the activities of a given occupation or function to the standards expected in employment (International Board of Standards for Training and Performance Instruction [IBSTPI], 2005). In the physics, chemistry and technology curriculum, a competency is defined as a “savoir-faire” based on the mobilization and efficient utilization of a set of resources (capabilities, skills and attitudes, knowledge, techniques…) acquired in scholastic or extra-scholastic context. Therefore, to be competent is to be capable to recall adequate resources, to efficiently combine them, and to wittingly use them. A competency’s wording should be embedded within its realization and evaluation context.
Three types of competencies are included in the physics, chemistry and technology curriculum: transversal, trans-disciplinary, and disciplinary competencies (MEPS, 2003). These competencies are not isolated; instead, they overlap and form a coherent set called life’s competencies. There are eight transversal competencies and six trans-disciplinary. The number of disciplinary competencies varies between two or three depending on the specific subject matter. Each competency is divided in capacities which are also separated in abilities.

Transversal competencies are characterized by a high degree of generalization and are acquired and developed because of trans-disciplinary, and disciplinary competencies. Transversal competencies are divided up in three categories: intellectual, methodological and socio-emotional. For example, in TE, a student demonstrates a transversal competency when utilizing available information, solving a given problem with appropriate resources, thinking critically, and working creatively and in collaboration with other students.

Trans-disciplinary competencies deal with the domains of common life. Their acquisition and development are realized through other disciplines and fields of training called “Champ de Formation” [Training Fields]. For example, a student displays a trans-disciplinary competency when affirming his personal and cultural identity, acting individually and within a group with mutual respect an open-mindedness, and getting information, making appropriate choices, and taking action related to his desires, his abilities, and his social realities.
Disciplinary competencies are the constituents of the New Study Programs. They relate to the domains of knowledge and are aimed at the appropriation of the designed program. For example, in TE, a student displays a disciplinary competency when he is able to elaborate an explanation of a fact or a phenomenon of one’s natural or constructed environment by implementing reasoning related to the physics, chemistry and technology, make use of the physics, chemistry and technology process for the making, utilization and repairing of technological objects, and appreciate the contribution of physics, chemistry and technology in human life.

Teachers’ Professional Development

The success of an educational reform is based on the teachers’ active participation and their effective preparation. Well prepared and sensitized to teach students, these teachers should gain knowledge and get acquainted with the strategies emphasized by the New Study Programs through training sessions and personal readings. Educators agree that the success of any curriculum reform resides in its implementation. Implementing the curriculum in science, technology, and mathematics successfully depends on well trained and motivated teachers; adequate supply of relevant equipment; learner friendly teaching and learning environment; positive attitude to science, technology, and mathematics, and development of a scientific culture (Bajah, 2000). In order to play his role, the teacher will adequately prepare for his class by: supporting students’ real and active participation during the execution of the learning activities; guiding them individually or collectively so to follow the scientific process projected in the concept construction phase; leading them while objectively discussing their peers’ results; helping them take notes of
important ideas; prompting and encouraging them to review the acquired knowledge, skills, competencies, and attitudes; explain the use of that knowledge in the future; and assess students’ work and proceed to a reinforcement if needed.

Rationale for the Study

Educational leaders in Benin have already developed mandatory national curriculum for science and TE in middle schools. This curriculum is seen as an essential catalyst to improve healthy living and a stronger economy with multiple employment opportunities for skilled people. Teachers have been expected to teach TE lessons since 2005. However, in a preliminary study, this researcher found that senior education officials in Benin are aware of the fact that the technology education/pre-engineering portion of the new science curriculum is not being implemented. Other findings from the preliminary study indicate that teachers are stressed by lack of background knowledge for TE, lack of PD opportunities to address this gap, absence of materials for performing hands-on activities with students, and lack of strategies for assessing student use and understanding of basic achievements in pre-engineering projects. The proposed study was to provide some base-line information on effective elements and design of PD of teachers for TE in Africa. Currently, there is very little information on professional development’s effects on teachers’ learning and professional attitudes and/or students’ achievements in developing countries. Also, researchers have suggested that the concept of self-efficacy be investigated in more depth to distinguish it from other constructs such as teacher expectations (Good, 1987).
Statement of the Problem

Several conferences, such as the World Conference on Education For All in Jomtien, Thailand in 1990, the World Summit for Children in New York in 1990, the World Education forum in Dakar, Senegal in 2000 and the World Summit on Sustainable Development in Johannesburg, South Africa in 2002, have called for improving the quality of basic education in developing countries. Recently, the World Conference on Science and Technology Education in Perth, Western Australia in July 2007, has demonstrated that science and TE is a universal requirement and contributed to three of the Education for All goals (The World Bank, 2009): attainment of the skills for youth (goal 3), elimination of gender disparities in education (goal 5) and enhancement of the overall quality of education (goal 6). In addition, among the recommendations to governments of the Perth Declaration on Science and Technology Education, it was suggested: (a) to promote critical awareness of the contribution of science and technology to personal, social, economic and environmental wellbeing through building partnerships with national stakeholders and the media; (b) to initiate revisions of the curriculum for school science and technology that will increase student interest in and recognition of the roles of science and technology in society; and (c) to resource and promote continuous, effective professional development for science and technology teaching in order to meet changing student needs and societal aspirations (World Conference on Science and Technology Education, 2007).

Scholars in education acknowledged that TE nowadays has a positive impact on society and on students. Raisen (1997) highlighted TE integration in science, in
mathematics, and in other subject matters in school settings and distinguished eight categories of TE approaches in schools used in Europe, in the United States, and Australia. These categories are the craft-based approach, occupational or vocational approach, high-tech approach, applied approach, technology concepts approach, design approach, science/technology/society (STS) approach, and integrated subjects approach. He claimed that the integrated science mathematics and technology (SMT) approach adopted nationwide in the United States and in other countries, has a great significance on students’ achievements and their future in society.

Also included in the acceptance of integrated SMT is the growing concern that the students of tomorrow will be seriously handicapped if they are unable to apply what they know from studying the three subjects separately. The integrated SMT approach is seen as an important step in helping students to become accustomed to and proficient in solving problems that have not as yet been identified, and to gain skills in acquiring knowledge that has not yet been developed. (Raisen, 1997, p. 64)

Since the above-mentioned conferences, many educational reforms have been implemented in the developing world, especially in Africa, to integrate science and technology in schools curriculum. Bajah (2000) acknowledged that:

The curriculum revolution all over the educated world in the second half of the last century had its effect on Africa. The African Curriculum Organization (ACO) picked up the challenge of curriculum renewal in Africa and over the years, new relevant and innovative curricula in Science, Technology, Mathematics and other school subjects have been produced all over Africa. (p. 5)
However, the sad observation is that these curriculum reforms described as “innovative” by UNESCO officials are only on paper. A review of studies in Africa reveals that the state of accomplishment of these reforms in most countries is dismally low. For instance, a South African study made the following observation: “At secondary level, the quality of science and mathematics education, particularly at African schools, is extremely poor, because the teaching of these subjects is done by unqualified or underqualified teachers, the facilities are poor and the classes are often too large” (STME report, 1993).

The crucial role of the teacher in bringing about meaningful educational change has been recognized in both the developed and developing countries. In the USA, The Holmes Group study (1986) on educational reform gave recognition to the importance of teachers in educational reform while stating:

… Curriculum plans, instructional materials, elegant classrooms and even intelligent administrators cannot overcome the negative effects of weak teaching or match the positive effects of positive teaching… The entire formal and informal curriculum of the school is filtered through the hearts and minds of classroom teachers, making the quality of school learning dependent on the quality of teachers. (p. 23)

Also in developing countries, many proposals have been put forward that stressed the role of teachers. For example, Bacchus (1991) proposed a list of five innovative approaches to curriculum practice and argued that if basic education is to be useful at all in improving the lives of the masses in the developing countries, then the preparation of teachers in
alternative and innovative approaches to classroom practice should be of central
importance in any attempt at educational change.

Similar to other developing nations, the Republic of Benin has implemented a
curriculum reform at the secondary level integrating TE into the science curriculum.
Benin curriculum leaders, aware of international demands in terms of technological
education, designed what should be taught, how and when it should be taught, how
evaluation and assessment should be carried out, and what in-service training was needed
for teachers to meet the educational goals of the *New Study Programs*. However, for his
end-of training for the inspectorate degree for secondary schools, Zannou (2004)
produced a thesis that stressed the sad reality regarding the implementation of the new
curriculum with sixth grade teachers selected from the 90 experimental schools. Besides
other issues pertaining to education in the developing countries evoked earlier, Zannou
found two main issues related to PD of these teachers.

The first issue raised by the participating teachers was the trainers’ expertise in
teaching TE. Teachers did not learn about TE as such and they did not carry out any
designs or artifacts because the trainers also did not have the basic background
knowledge. As a result, they indicated that the PD did not impact their learning and
behaviors and did result in a waste of time. In addition, the PD was ill designed because it
did not align pedagogy and content knowledge with the requirements of the new
curriculum.

The second issue was the lack of sustainable PD in TE. The teachers indicated
that they need periodic PD instead of the “one-shot” trainings performed for the
implementation phase of the new curriculum. Guskey (2000) described PD as an ongoing process, explaining that in order, “to keep abreast with new knowledge and understanding, educators at all levels must be continuous learners throughout the entire span of their professional careers” (p. 19). This lack of ongoing training did not allow educators to effectively teach the entire curriculum.

Some researchers insist on the importance of completing some fieldwork prior to writing a research proposal and further caution that designing a study without preliminary observations or interviews can lead to unfocused armchair theorizing or overly speculative frameworks to which one can become prematurely committed (Bogdan & Biklen, 2007; Strauss, 1987). Therefore, in a preliminary study carried out recently with Benin secondary school inspectors and some teachers related to the implementation of the TE portion of the physics, chemistry and technology curriculum, the researcher found that because of the trainers’ lack of expertise in TE and the above-mentioned dearth of sustainable PD, middle science teachers are not teaching the TE chapters. They expressed their dislike for teaching it, their lack of efficacy to go before students to teach, and even their lack of courage to mention it in their class. Teachers who claimed to be willing to try it out with their students are reluctant for many reasons such as lack of materials, teaching load, and large class size. Therefore, students are going through the middle schools and high school without having the required instruction and knowledge in TE.

Under these circumstances and based on Zannou’s (2004) suggestions for further research, the major problem to be investigated in this study was Benin middle school science teachers’ self-efficacy beliefs to teach the required part of TE. Implementation of
the PD including the learning of the content knowledge and the teaching of TE, the
making of artifacts, and the designing of assessment tools to evaluate students’ works
was an essential component for investigating teachers’ self-efficacy to teach the subject
matter.

**Theoretical Framework of the Design**

The theoretical framework of the study sets the ground for formulating the
research questions, designing the study, analyzing and interpreting the data. This research
study is based on the effectiveness of the TEPD program designed for middle school
science teachers, which is related to the concept of teacher change.

Teacher change deals particularly with “the profound paradigm shift in
conceptions, in beliefs, expectations, and dispositions, in practice that teachers have to
undergo in order to carry out the current reforms in education, reforms that require re-
examination of traditional knowledge and practice” (Hashweh, 2003, p. 421). Going
through the change process, teachers face three possible outcomes of cognitive conflict.
Progressive outcomes occur when teachers undergo accommodative change. Hashweh
noted that teachers undergo accommodative change when “they are internally motivated
to learn; become aware of their implicit ideas and practices and critically examine them;
construct alternative knowledge, beliefs, and practices; resolve the conflicts between the
prior set of ideas and practices and the new” (p. 421). Educational psychologists, social
constructivist, and other scholars in education identified differently ideas of learning. The
most important finding is the idea that learning links new knowledge to prior knowledge.
Learning is constructed in a social context; it is goal oriented, strategic, situated, and rationalistic.

New knowledge in itself does not bring about change; PD must engage teachers’ beliefs, experiences, and habits (Valli & Hawley, 2002). An extensive literature exists on “professional development and teacher change” (for example, Fullan & Stiegelbauer, 1991; Dalin, 1978; Jones & Simon, 1991; Van den Akker, 1988). This literature permits various readings of the term “teacher change” and Clarke and Hollingsworth (1994) identified a number of alternative perspectives. These authors indicated that historically, teacher change has been directly linked with planned PD activities. Therefore, they suggested that while the notion of teacher change was open to multiple alternative perspectives, which are not mutually exclusive, each interpretation could be associated with a particular perspective on teacher PD. Some of the perspectives on teacher change are:

- Change as training -- change is something that is done to teachers; that is, teachers are “changed”.

- Change as adaptation -- teachers “change” in response to something, they adapt their practices to change conditions.

- Change as personal development -- teachers “seek to change” in an attempt to improve their performance or develop additional skills or strategies.

- Change as local reform – teachers “change something” for reasons of personal growth…
• Change as growth or learning – teachers “change inevitably through professional activities.” (Clarke & Hollingsworth, 2002, p. 948)

These perspectives on teacher change are embedded within the goals of the TEPD program designed for this study. Indeed, through the PD, the researcher envisions change as training, adaptation, personal development, local reform, and growth or learning.

It is the intention of the study to provide selected teachers with an effective training in order to change their attitudes and beliefs. The PD was to enhance teachers’ self-efficacy beliefs to teach TE lessons. In Bandura’s (1977) theory, self-efficacy comprises personal self-efficacy expectations and outcome expectancy. Change as adaptation will occur, as teachers’ personal self-efficacy will be enhanced, as they will gain the conviction to successfully teach TE and impact students’ learning. They will voluntarily accept to teach the new curriculum that integrates TE in the science curriculum. Also, change as adaptation will take place, as a result of teachers’ outcome expectancy enhancement, as they will acknowledge that teaching TE will develop students’ skills and their well-being in Benin society.

Lieberman and Miller (2002) advise that PD needs to be developmental and adaptive in its approach; it has to acknowledge the needs and concerns of individuals and the personal connections they make to their classroom. Through the selected activities included in the TEPD, change as personal development will happen, as teachers’ attention and curiosity will increase, so that they could learn to acquire new teaching strategies and skills. Change as local reform will take place, as teachers will learn the content of TE and the pedagogical content knowledge in order to be able to adequately
teach TE. Teachers will gain technology education/pre-engineering skills. They will learn how to design and make model artifacts, and how to repair diverse objects.

Finally, it is the intention of the study to bring change to teachers through the TEPD. It is expected that teachers will learn and apply the knowledge gained, and that they will acknowledge the significance of the help provided.

Purpose of the Study

This study has two major purposes: a research purpose and a practical purpose (Maxwell, 1996). The research purpose of the study was to explore these teachers’ TE content knowledge and pedagogical content knowledge, and teachers’self-efficacy beliefs to teach the TE part of the curriculum after participating in a PD designed to assist them. The researcher’s research purpose was led by his motivation to develop an understanding of factors enhancing teachers’ self-efficacy to teach TE to students and allowing them to teach new topics.

The practical purpose of the study was to provide Benin middle school teachers with an effective TEPD which would grant teachers with four different experiences: (1) learning about TE; (2) learning to teach TE; (3) learning to design hands-on models in TE; and (4) learning to design rubrics in order to assess their own works and students’ works as well. Teachers would learn TE content knowledge, how to make different artifacts, how to teach children to design devices and bring changes in their cognitive skills, and how to apply some key ideas about assessing students’ work. Overall, teachers will be acquainted with areas of competencies to develop in the student that are specified in the competency-based curriculum for use in Benin secondary school system.
Consequently, the researcher’s practical purpose was to help teachers in his home country to teach effectively for student achievement. Aware of the lack of training for teachers in Benin’s education system, the researcher’s priority was the development of effective, continuous PD in order to always keep educators informed about the incessant evolution of knowledge in science and technology.

Research Questions and hypotheses

Research Questions

The theoretical framework of this study, in addition to the problem statement and the purpose of the study expounded earlier, helped to frame the research questions that are:

1. What are the effects of technology education professional development (TEPD) on Benin secondary school science teachers’ efficacy beliefs?
2. Do Benin secondary school science teachers acquire content knowledge through the TEPD program?
3. Do Benin secondary school science teachers acquire pedagogical content knowledge through the TEPD program?
4. To what extent do Benin secondary school science teachers teach the technology education lessons in their classroom following the TEPD?
5. How do Benin secondary school science teachers perceive their own TEPD experience?
Hypotheses

Five working hypotheses (Bogdan & Biklen, 1998) emerge from the research questions giving meaning to the data analysis. The fundamental hypothesis related to the first question of this study is that the participation of Benin secondary school science teachers in the TEPD program will result in enhancement of their self-efficacy in teaching TE, meaning their personal TE teaching self-efficacy and outcome expectancy will increase. Teacher self-efficacy is the realization of one’s self-judgments and capabilities to create and organize instruction that motivate student learning (Onafowora, 2004). The second question is related to the content of the PD program. Therefore, The researcher theorizes that by participating in the PD program, teachers’ TE content knowledge will be enhanced. They will learn the foundations of TE and get acquainted with the TE lessons included in their curriculum. The speculation underlying the third research question is that teachers will obtain pedagogical content knowledge for the subject matter under question. Teachers will acquire the needed technology education/pre-engineering skills enabling them the necessary confidence in teaching TE in their classroom. For the fourth research question, the researcher hypothesizes that teachers’ opinions regarding teaching of TE will change and they will effectively apply the knowledge gained after participating in the TEPD program and change their classroom practices, meaning successfully teach the TE lessons that are part of the compulsory science curriculum in Benin. Finally, the fifth hypothesis indicates that after participating in the PD, teachers will acknowledge its soundness and its effectiveness.
Teachers’ impressions after the training will definitively be favorable, as they will acquire the necessary knowledge and skills to face adequately the constraints of their job.

Definition of Major Terms

Essential terms or major concepts that are recurrent and seem important in the study include PD, technology education, teacher beliefs, and self-efficacy. Therefore, in order to help the reader grasp the content of the study, an operational and explicit definition of these terms will be provided.

**Professional Development**

Guskey (2000) defines PD as “those processes and activities designed to enhance the professional knowledge, skills, and attitudes of educators so they might, in turn, improve the learning of students” (p. 16). Bybee and Loucks-Horsley (2000) after pointing out the role of PD in TE indicated that effectiveness of PD should pay attention to four needs: (1) teachers need to learn about and develop skills related to technology; they need opportunities to deepen their content knowledge; (2) teachers need opportunities to learn about how to teach technology, combining their content knowledge with what they know about learning and how to teach their particular content; (3) teachers need tools to help them continue their own learning and the motivation to do so; and (4) teachers need sustained professional development programs in order to get them both depth and breadth in what they need to know and be able to do. The focus of this study is to address the first three needs.
Technology Education

For the purpose of this study, TE is the school subject in which students learn to design and make products that are useful both to themselves and to other people; it is both intellectual and practical (Welch, 2007). It introduces students to the powerful process of designing; it requires creativity and problem-solving abilities. Technology education deals with all the dimensions of technology including knowledge, ethics, philosophy, and politics. Overall the development of TE impacts people’s life. Thus TE is that aspect of education that helps to “facilitate the incorporation of scientific and technological development into the multiple (complex) realms of our life” (Pena, 1994). Furthermore, TE also enables an individual to gain the “capacity to comprehend technology, its relation with nature, society, culture, thereby giving individuals and the institutions they create criteria to use technology consciously and responsibly” (Ojo, 1996, p. 6).

Teacher Beliefs

Teacher beliefs are a particularly provocative form of personal knowledge that is generally defined as teachers’ implicit assumptions about students, learning, classrooms, and the subject matter to be taught (Kagan, 1992). In the literature, the term “teacher belief” is not consistently used. Some researchers mention instead teachers’ “principles of practice,” “personal epistemologies,” “perspectives,” “practical knowledge,” or “orientations.” Despite great variety in focus, empirical studies have yielded quite consistent findings in regard to two generalizations. First, teachers’ beliefs appear to be relatively stable and resistant to change (e.g., Brousseau, Book, and Byers, 1988;
Herrmann and Duffy, 1989). Second, a teacher’s beliefs tend to be associated with a congruent style of teaching that is often evident across different classes and grades levels (e.g., Everston and Weade, 1989; Martin, 1989).

**Self-efficacy**

The term efficacy is characterized as “a personality trait that enables one to deal with the world” (Barfield & Burlingame, 1974, p. 10). Albert Bandura who was the first to introduce the construct of self-efficacy over a quarter of century ago, provided various definitions of that concept that are related to the beliefs and judgments one makes pertaining to a labor to be accomplished. He defined self-efficacy as “beliefs in one’s capabilities to organize and execute the course of action required to produce given attainments” (Bandura, 1997, p. 3). Such beliefs are the most central mechanism of personal agency. Self-efficacy may be defined as a belief in one’s own abilities to perform an action or activity to achieve a goal or task (Bandura, 1997).

Precise definitions of teacher efficacy have been always problematic (Guskey, 1998). Teacher efficacy is defined as “the extent to which the teacher believes he or she has the capacity to affect student performance” (Berman, McLaughlin, Bass, Pauly, & Zellman, 1977, p. 137). Ashton (1985) defines it as “teachers’ beliefs in their ability to have a positive effect on student learning” (p. 142); while Guskey and Passaro (1994) indicate that “efficacy is perceived as teachers’ beliefs or conviction that they can influence how well students learn, even those who may be considered difficult or unmotivated” (p. 628). While these definitions are valuable, Berman et al.’s and Ashton’s
definitions are appropriate for the purpose of this study because these authors’ definitions are consistent with Bandura’s; whereas Guskey and Pasaro’s is little different.

**Significance of the Study**

The study was designed to: (1) provide Benin middle school teachers with a TE professional development program to provide them with the opportunity to learn about TE, how to teach it, how to design artifacts, and how to design assessment tools to evaluate students’ works; and (2) assess potential changes in these teachers’ TE content knowledge and pedagogical content knowledge, and in their self-efficacy beliefs to teach TE in their class. The implementation of the TEPD and the findings of the research per se could be of great interest to the teachers, to the Ministry of Primary and Secondary Education (MPSE), to the National Institute for Training and Research in Education, to Benin international partners in education, and to the researcher.

*Significance of the Study for Teachers*

It is well known that any educational reform cannot succeed without teachers’ PD. For teachers, the significance of the implementation of the TEPD was manifold. First, it would provide teachers with the skills, the content knowledge in TE, and the confidence needed to teach the neglected portion of the new curriculum. Second, it might empower participating teachers to be able to teach other teachers. Finally, the PD may help teachers to ultimately improve students’ knowledge and skills to design and produce artifacts in TE.
Significance of the Study for the MPSE and Research Institutions

The implementation of the PD was to provide leaders in the Ministry of Primary and Secondary Education and in the research institutions with base-line information on effective elements and design of PD of teachers for TE. The findings of the study have the potential to inform these leaders about how to empower teachers while implementing an educational reform. Finally, the findings of the study was to provide research institutions, such the National Institute for Training and Research in Education in Benin, “some research-based data needed for a new public discourse in education in the future” (Clinchy, 1997).

Significance of the Study for Benin International Partners in Education

The Republic of Benin, a developing country, takes advantage of the help from developed countries and intergovernmental organizations, mostly in agriculture and in education. The implementation of this project and the findings of the study might indicate to Benin’s partners in which direction they might focus their attention while helping in education. Also, the findings of this study might benefit other developing countries.

Significance of the Study for the Researcher

The significance of the study for the researcher was threefold. First, it would offer him the opportunity to design, execute and evaluate a PD program which would help teachers of science and technology. Second, it would provide the researcher with the satisfaction to participate partly in resolving one of the educational problems faced by his country, the Republic of Benin. Finally, its findings might demonstrate the usefulness of PD project and will definitely provide a database which would benefit other researchers.
Summary

The context of the study, the rationale of the study, the statement of problem, a succinct presentation of the conceptual framework of the design, the purpose of the study, the research questions, and the possible significance of the study were the different sections encompassing this chapter. It was demonstrated that the study was needed in order to investigate these teachers’ TE content knowledge and pedagogical content knowledge and teachers’ self-efficacy to teach the TE lessons included in the curriculum. Also, the potential significance of the findings of the study was anticipated at different levels, precisely because of its unique character.
CHAPTER II
REVIEW OF RELATED LITERATURE

Introduction

This study encompasses two types of purpose. The practical purpose of the study was to provide Benin middle school teachers with an effective technology education professional development (TEPD) which would grant them with four different experiences: (1) learning about technology education (TE); (2) learning to teach TE; (3) learning to design hands-on models in TE; and (4) learning to design rubrics in order to assess their own products and their students’ works as well. In other words, by participating in the professional development (PD), teachers will learn about the TE content knowledge and the pedagogical content knowledge. The research purpose of the study was to explore these teachers’ TE content knowledge and pedagogical content knowledge, and teachers’ self-efficacy beliefs to teach the TE part of the curriculum after participating in the PD. The first chapter provided the reader with an overview of Benin education system, of the new curriculum called the New Study Programs, the rationale, the statement of the problem, and the significance of the study.

This chapter presents a review of the literature and scholarship related to the study. It contains six sections. The first section presents the concept of teacher change and the different models of teacher change proposed by scholars. The second deals with Bandura’s theory of self-efficacy. The third section presents models of teacher PD in Western countries and sub-Saharan African countries. The fourth copes with the general
concept of pedagogical content knowledge (PCK), in particular the PCK in TE. The fifth section touches on science and technology, underscoring views of their differences and their relationships. Finally, the sixth section presents a review of TE teaching in Africa.

Teacher Change

The literature on teacher change (Fullan, 1982; Smith & Gillepsie, 2007; Nathan & Knuth, 2003) indicates that there is a relationship between teacher change and PD programs. Furthermore, Griffin (1983) claimed that PD programs are designed to “alter the professional practice, beliefs, and understanding of school persons toward the articulated end” (p. 3). Smith and Gillepsie in a review of literature found two factors affecting how teachers change as a result of PD: (a) individual (or teacher) factors and the school factors. Individual factors encompass teacher motivation for PD, teacher concern, teacher self-efficacy, teacher cognitive styles or ways of knowing, teacher reflectiveness, and teacher formal education and years of experience. The school, program and system factors include leadership, coherence between PD topic and school, collegiality within school, and teachers’ working conditions. They recommended that understanding these factors can help professional developers and policymakers take action to provide the conditions supportive of teachers and, ultimately, student achievement.

Professional developers agree that “the goal of many professional development programs and activities is change in participants’ attitudes, beliefs, or dispositions” (Guskey, 2000, p. 138). In order to attain these goals, many models of teacher change have been proposed (for example, Clarke, 1988; Cobb, Wood, & Yackel, 1990; Johnson
While PD programs often attempt to change teachers’ beliefs and attitudes, with the expectation that changes in beliefs and attitudes will lead to changes in classroom practices and behaviors, Guskey (1986), in discussing such models, pointed out the flaws in this view of change and provided an alternative model (see Figure 1).

<table>
<thead>
<tr>
<th>Staff development</th>
<th>Change in teacher’s classroom practices</th>
<th>Change in students learning outcomes</th>
<th>Change in teachers’ beliefs &amp; attitudes</th>
</tr>
</thead>
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*Figure 1.* The Guskey (1985, 2002) proposed model of teacher change.

He stated that significant changes in beliefs and attitudes are likely to take place only after changes in student learning outcomes are evident, that is, once teachers have tested change proposals in classrooms and experienced first hand change in student learning outcomes. Many researchers (Crandall, 1983; Yamagata-Linch, 2003; Stein, McRobbie, & Ginns, 1999) have supported Guskey’s model. Whilst Guskey’s model has provided useful insight into some aspects of teacher change, it can also be criticized for representing teacher change as a strictly linear process (Clarke & Peter, 1993).

Clarke and Hollingsworth (2002) presented a model called “the interconnected model of professional growth,” whose key feature is its inclusion of the four analytic domains in close correspondence to those employed by Guskey (1986) and others. Based on an empirical data collection, the model emphasizes the specific mechanisms by which change in one domain is associated with change in another. The interconnected, non-
The linear structure of the model enabled the identification of particular “change sequences” and “growth networks”. While distinguishing the change environment from the key four analytic domains, the authors provided a thorough interpretation of their model.

The role of self-efficacy in teaching and learning continues to interest researchers and practitioners alike (Hoy & Spero, 2005). Khourey-Bowers and Simonis (2004) studied the influence of a longitudinal chemistry PD program on four discrete cohorts of middle grade teachers in terms of gains in personal science teaching self-efficacy, outcome expectancy, chemistry content, and pedagogical content knowledge. Pre- and post-test (using the Science Teaching Efficacy Belief Instrument (STEBI) form A for inservice teachers (Riggs & Enochs, 1990)), along with interviews were used for data collection. Findings indicated that significant changes were produced in self-efficacy at .01 in each cohort, personal science teaching self-efficacy was significantly enhanced in cohort 1, 2, and 4 at .01 and outcome expectancy was significantly enhanced in cohorts 1 and 3 at .01 and in cohort 5 at .05. The authors suggested that “professional development that enhances personal science teaching self-efficacy and outcome expectancy should be recognized as essential to achieving scientific literacy for all students” (p. 175).

Yamagata-Linch (2003) conducted research using a naturalistic methodology and designed two case studies based on the Teacher Institute for Curriculum Knowledge about Integration of Technology (TICKIT), which is a yearlong PD program for inservice teachers in rural Indiana K-12 schools. Teachers involved in this study were required, while guided, to integrate technology into their lessons plans. Among the five
overarching findings explaining how TICKIT fit into the participants teachers’ work life and their everyday decision-making, one of them pointed out that, TICKIT as a PD, empowered teachers who were discouraged by technological problems during the implementation of the program to nevertheless continue to use the lessons in their future classroom, because it motivated their students to learn. They reported that many students went above and beyond what teachers expected. Thus, the teachers decided to continue using the program after improvement in their students’ learning and achievement.

With a purposeful sampling of teachers voluntarily implementing a technology curriculum in their school, Barnes (2005) studied factors facilitating teachers’ implementation of a technology curriculum. The researcher noticed that one of the factors is the students’ enthusiasm, which provided the momentum for the ongoing change process. Through their narrative interviews, participants acknowledged “the students’ change from boredom with the traditional program, to a positive response to the technology curriculum, has encouraged the teachers to rethink their attitudes to existing curricula” (p. 10). The attitudes and beliefs of teachers implementing a TE curriculum could then be changed positively due to students’ eagerness to learn the subject matter. In addition to these findings, the authors designed two leadership models of curriculum change called a “Trendsetter model of non-systemic curriculum change in technology education” (p. 13) and “Promoter model of non-systemic curriculum change in technology education” (p. 14). Trendsetter model provides a teacher with the opportunity to question his/her belief in TE. In that model, flagging student interest, the external
curriculum, and the personal renewal influence a teacher’s desire to change the curriculum. Promoter leadership model is based on a teacher’s experience of being willing to accept new ideas related to TE ideals, in order to support systematically and purposefully the work of others. The model therefore involves a promoter leadership style nucleus that is acted on by the three factors cited above.

Stein, McRobbie, and Ginns (1999) utilized an interpretive research design to explore the issues and concerns identified by three upper primary school teachers implementing technology ideas using an Australian curriculum document. The case study of one of the teachers is used to illustrate how the teachers implemented TE, working from their own perspectives and tackling issues and concerns that made sense to them. Agreeing with other researchers, Stein et al. acknowledged that teachers are the primary agents of their own development, which builds as they experience relationships with their students and with the curriculum innovation within their classrooms. One of the implications of the study stipulated that when considering the PD needs of teachers beginning implementation of TE, thought should be given not only to teachers’ understanding of technology, but also to their understanding of teaching and learning within the technology context and to how that understanding may change with time. The teachers need to see the reasons for making changes in their beliefs and practices and they have to experience the value of those changes in terms of seeing that the children are learning.
Many studies have investigated teachers’ self-efficacy in science teaching and others have explored the integration of technology in the classroom. However, no one has conducted research dealing with TE in middle schools on teachers’ self-efficacy beliefs in Africa, particularly in the Republic of Benin.

Bandura’s Theory of Self-Efficacy

Based on social cognitive theory (Bandura, 1994), self-efficacy is described as “people’s beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives” (p. 72). Bandura (1977) designed a theoretical framework in which self-efficacy expectations are distinguished from response-outcome expectancies, based on his social learning analysis. Outcome expectancy is defined as a person’s estimate that a given behavior will lead to certain outcomes; whereas an efficacy expectation is the conviction that one can successfully execute the behavior required to produce the outcomes.

Bandura’s (1986, 1997) model postulated that there are four sources of efficacy expectations: mastery experiences, physiological and emotional states, vicarious experiences, and social persuasion. Mastery experiences are the most powerful source of efficacy information. The perception that a performance has been successful raises efficacy beliefs, which contributes to the expectation that performance will be proficient in the future. The perception that one’s performance has been a failure lowers efficacy beliefs, which contributes to the expectation that future performances will also be inept. The level of arousal, either of anxiety or excitement, adds to the feeling of mastery or
incompetence. Attributions play a role, as well. If a success is attributed to internal or controllable causes such as ability or effort, then self-efficacy is enhanced. But if success is attributed to luck or the intervention of others, then self-efficacy may not be strengthened (Bandura, 1993; Pintrich & Schunk, 1996).

Many expectations are derived from vicarious experience. Seeing others perform threatening activities without adverse consequences can generate expectations in observers that they too will improve if they intensify and persist in their efforts. They persuade themselves that if others can do it, they should be able to achieve at least some improvement in performance. The more closely the observer identifies with the model, the stronger will be the impact on efficacy. When the model with whom the observer identifies performs well, the efficacy of the observer is enhanced. When the model performs poorly, the efficacy expectations of the observer decrease.

In attempts to influence human behavior, verbal persuasion is widely used because of its ease and ready availability. People are led, through suggestion, into believing they can cope successfully with what has overwhelmed them in the past (Bandura, 1977). Although social persuasion alone may have definite limitations as a means of creating an enduring sense of personal efficacy, it can contribute to the successes achieved through corrective performance. That is, people who are socially persuaded that they possess the capabilities to master difficult situations and are provided with provisional aids for effective action are likely to mobilize greater effort than those who receive only the performance aids.
According to Midgeley, Feldlaufer and Eccles (1989), in addition to being related to student achievement, teacher’s sense of efficacy has been associated with other student outcomes such as motivation and students’ own sense of efficacy. Research showed that teachers’ efficacy beliefs appear to affect the effort teachers invest in teaching, their level of aspiration, and the goals they set. If Bandura’s theory of self-efficacy is applied to the study of teachers, one might predict that:

… teachers who believe student learning can be influenced by effective teaching (outcomes expectancy beliefs) and who also have confidence in their own teaching abilities (self efficacy beliefs) should persist longer, provide a greater academic focus in the classroom and exhibit different types of feedback than teachers who have lower expectations concerning their ability to influence students learning (Gibson & Dembo, 1984, p. 570).

Indeed, teachers with a strong sense of efficacy tend to exhibit greater levels of planning, organization, and enthusiasm (Allinder, 1994) and spend more time teaching in subject areas where their sense of efficacy is higher (Riggs & Enochs, 1990), whereas teachers tend to avoid subjects when efficacy is lower (Riggs, 1995). Teachers with higher efficacy judgments tend to be more open to new ideas, more willing to experiment with new methods to better meet the needs of their students (Cousins & Walker, 2000; Guskey, 1988; Stein & Wang, 1988), and more committed to teaching (Coladarci, 1992). Efficacy beliefs influence teachers’ persistence when things do not go smoothly and their resilience in the face of setbacks (Gibson & Dembo, 1984). A greater sense of efficacy
enables teachers to be less critical of students who make errors (Ashton & Webb, 1986), to work longer with a student who is struggling (Gibson & Dembo, 1984), and to be less inclined to refer a difficult student to special education (Meijer & Foster, 1988; Soodak & Podell, 1993).

Finally, it is important to note that many instruments are utilized to explore teachers’ self-efficacy beliefs. The science teaching efficacy belief instrument (STEBI) form-A (Riggs and Enochs, 1990) is used in the field of science teaching; especially in chemistry teaching. Rubeck and Enochs (1991) utilized the STEBI-CHEM. In the teaching of mathematics, the mathematics teaching efficacy beliefs instrument (MTEBI) (Enochs, Smith, & Huinker, 2000) is commonly used by researchers. Also, in order to investigate teachers’ self-efficacy in teaching appropriate Internet usage, Watson (2006) designed a survey called the personal Internet teaching efficacy beliefs scale (PITEBS). Each of these instruments is comprised of two subscales: personal teaching expectancy (PSTE) and teaching outcome expectancy (STOE). In addition, they appear to have a high validity and reliability. For example, for STEBI, the subscale PSTE has a coefficient alpha reliability of .92, and .77 for the STOE. For the MTEBI, the reliability analysis produced an alpha coefficient of internal consistency (Cronbach alpha) of 0. 88 for personal mathematics teaching efficacy (PMTE) scale, and of 0. 77 for the mathematics teaching outcome expectancy (MTOE) scale (Enochs, Smith, and Huinker, 2000).
Models of Teacher Professional Development

Professional development is of great significance in every nation’s school reform. Actually, since the time of the early Greeks, PD has been a part of education. Originally known as staff development, it was initiated in the US in the 1980s as a solution to a growing concern in the early 1970s concerning the effectiveness of in-service education. It was the focus of countless conferences, workshops, articles, books, and research reports (Sparks & Loucks-Horsley, 1989). This section stresses what the literature indicates as models of teacher PD in developed countries as well as in sub-Saharan African countries.

Models of PD in Developed Countries

In the US and European countries, the past three decades have seen the emergence of a range of models of teacher PD, some of which emphasize cognitive growth (Sprinthall et al., 1996), others emphasize epistemological development (Perry, 1970), while others amalgamate a range of conceptual, personal and social dimensions (Guskey, 1986; Bell & Gilbert, 1996). Some models are clearly delineated, while others are either misleading or confound models of PD with strategies of PD delivery. Still, some of these models are more behavioristic in their approach (Tyler, Smith, & Grover, 1999) with a focus on exploration of theory, demonstration or modeling, practice of the skill, feedback from the experts and further coaching in the workplace. “These models present educators with a wide range of options and opportunities to enhance their professional knowledge and skills” (Guskey, 2000, p. 12).
Sparks and Loucks-Horsley (1989) suggest five models, including individually-guided staff development, observation and assessment, involvement in a development or improvement process, training, and inquiry. Individually-guided staff development refers to a process through which teachers plan for and pursue activities they believe will promote their own learning. The observation and assessment model provides teachers with objective data and feedback regarding their classroom performance. Involvement in a development or improvement process engages teachers in developing curriculum, designing programs, or engaging in a school improvement process to solve general or particular problems. The inquiry model requires that teachers identify an area of instructional interest, collect data, and make changes in their instruction based on an interpretation of those data. The training model involves teachers in acquiring knowledge or skills through appropriate individual or group instruction.

Guskey (2000) proposes in his list the same models as Sparks and Loucks-Horsley, but he adds study groups and the mentoring models. Guskey asserted that the study groups’ model involves the entire staff of a school in finding solutions to common problems. Staff members are generally divided into groups of four to six members each; each group selecting a different aspect of the problem on which to concentrate. He also defined the mentoring model of PD as involving pairing an experienced and highly successful educator with a less experienced colleague. Regular opportunities are then provided for discussions of professional goals, the sharing of ideas, and strategies on
effective practice, reflection on current methods, and on-the-job observation and tactics for improvement. Finally, he specifies the advantages of each of these models.

Lieberman and Wilkins (2006) offer a PD pathways model in which school districts can meet the individual PD needs of its staff. Within the model, a continual cycle occurs in which a needs assessment is conducted whereby the results are matched with PD standards. Allan and Miller (1990) and Feist (2003) developed two different types of models called the collaborative models, which encompasses several stages or phases. Other models include helping teacher model (Rauh, 1978), and staff development for school change model (Miller & Wolf, 1978).

Guskey & Loucks-Horsley, (1989) assert that in the minds of educators, training is synonymous with staff development; it is the most common form of PD and the one with which educators have the most experience. They also provide details about the characteristics, assumptions, theoretical research underpinnings, and phases of this model of PD. Guskey (2000) discussed the advantages and drawbacks of training and summarized it as follows:

Training is the most efficient and cost-effective professional development model for sharing ideas and information with large groups of educators. It provides all participants with a shared knowledge base and a common vocabulary… The major shortcoming of training is that it offers few opportunities for choice or individualization. Hence it may not be appropriate for the varied levels of educators’ skills and expertise. (p. 23)
Joyce and Showers (1988) have conducted an intensive research on training as a model of PD. They have determined that, depending upon the desired outcomes, training might include exploration of theory demonstration or modeling of a skill, practice of the skill under simulated conditions, feedback about performance, and coaching in the workplace. Finally, they indicate that outcomes of training comprise awareness or knowledge, skill development, changes in attitudes, transfer of training, and executive control.

Sparks (1983) cites the importance of discussion and peer observation as training activities. He notes that discussion is useful when both new concepts and techniques are presented and as a problem-solving tool after teachers have had an opportunity to try out new strategies in their classrooms. Along with Loucks-Horsley et al. (1987), Sparks indicates that training sessions that are spaced one or more weeks apart so that content can be “chunked” for improved comprehension and so that teachers have opportunities for classroom practice and peer coaching are shown to be more effective than “one-shot” training. Sparks (1983), Wood and Kleine (1987) and Wu (1987) point out the value of teachers as trainers of their peers. Sparks indicates that teachers may learn as much from their peers as from “expert” trainers. Administrators and the trainer often determine the different phases of activities – content, objectives, and schedule – of training. Still, the research-based model introduced by Wood, McQuarrie, and Thompson (1982) advocates involving trainees in planning training programs.
Models of PD in Sub-Saharan African Countries

Sub-Saharan African countries have inherited from their former colonizers the use of a principal language – French or English – which is the official language and the language of instruction of the designated country. For example, the Republic of Benin, Niger, Burkina Faso, and Ivory Coast are French-speaking countries, whereas Ghana, Nigeria, and Sierra Leone are English-speaking countries. Due to the state of the poverty of these countries, schooling constitutes a great problem of development. On the other hand, despite the difficulties education is facing in sub-Saharan Africa, the existing literature shows that teacher PD occurs within the context of educational reforms and precisely following a curriculum change. Therefore, teacher PD in sub-Saharan Africa generally takes the form of training, in order to provide the in-service teacher with the necessary skills and content knowledge to teach the new curriculum. In general, training involves a presenter or team of presenters who establishes the content and flow of a variety of group-based activities. Typically, the “expert” trainer or presenter comes either from France or England depending on the official language of the country. Training formats used in sub-Saharan African countries include lectures, workshops, seminars, colloquia, demonstrations, simulations and micro-teaching. A number of quite different approaches to training have been developed in recent years. As a result of the contemporary pressures on teachers and on teacher training institutions, the most frequently used model is the participatory teacher training that is in use in certain countries of West Africa.
Shaeffer (1990) provided a thorough description of participatory teacher training in sub-Saharan African countries, recognizing its five characteristics. Pertaining to the first characteristic, the teacher plays an active role in the training process and is therefore not a passive recipient of others’ accumulated knowledge about methods and content. The teacher becomes a participant in decisions regarding the needs to which training must respond, problems it must solve, and skills and knowledge it must transmit. Consequently, as second characteristic, training becomes self-directed and the teacher self-taught. The autonomous nature of the teacher in the classroom is recognized in the training itself as he or she is encouraged to assess problems and design and experiment with appropriate solutions. The third characteristic is that training is based on reflection and introspection. Instead of being presented by outside observers or experts, teachers define, examine and analyze for themselves their needs, problems, status, roles, etc. Related to the fourth characteristic, participatory training bases teacher introspection on the actual, concrete experiences of working with children in classrooms and schools. Finally, for the fifth characteristic, the group often structures participatory training, though based ultimately on individual reflection, autonomy, and action. Teachers collectively examine and analyze their experiences, assisted by trainers working more as facilitators and resource persons rather than experts, and so cooperate in solving problems and learning from each other. In his review of the literature, Shaeffer (1990) finds that there is a wide variety of methods and approaches of delivery about how to achieve the objectives of participatory training. The most common include cooperative
learning, reflective-instruction, training by “simulation and situation,” and the teacher as researcher.

In the cooperative learning approach to participatory teacher training, teachers and trainers work together to establish needs, identify problems, suggest and evaluate possible solutions, and in so doing, develop curriculum, syllabi, methods, or texts. In sub-Saharan African countries, this approach does not involve the development of curriculum, but the development of lesson plans; as in most of these countries, the curriculum is mandated nationwide. Approaches to cooperative learning are seen in teacher’s centers and workshops. Teacher’s centers are usually places (model schools, district offices, and training colleges) where practicing teachers come for guidance, training, and information. In the workshop approach, usually teachers from several schools are grouped in order to mutually develop their abilities with the help of a facilitator.

Reflective self-instruction is based on self-renewal, often through some form of distance education. (e.g. radio, correspondence, courses, self-instructional modules, etc). This type of training is participatory when it encourages a learner to become autonomous, self-reliant, and active in learning, and then to reflect on this learning. Special radio broadcasting courses exist particularly in the Republic of Benin to provide information to inservice teachers about the different objectives of the curriculum and to provoke their reactions. Another form of self-instruction includes the use of manuals, modules, and guides. Because of the lack of necessary textbooks in most of the countries, this form of
training is in vogue to minimize the cost of teaching in relation to the implementation of a new curriculum.

The training by “simulation and situation” method is practiced in Benin, Niger, Togo and other countries in West Africa. The training is grounded in concrete, school-based situations in a way that the trainees become active participants in the situations. For example, in the Republic of Benin’s secondary schools, pedagogic advisors, appointed by the Ministry of Education, are in schools working hand in hand with non-certified teachers. These teachers have the responsibility of designing and implementing their lesson plans in their classroom. The pedagogic advisor is responsible for observing the class and providing feedback and advice. In elementary schools, where most of the teachers are untrained and non-certified, principals and pedagogic advisors also work (sometimes during the weekends) with the trainees.

The teacher as researcher method is similar to the above-mentioned inquiry/action research model. Many aspects of participatory teacher training come together in this process: action, autonomy, self-direction, reflection on concrete reality, and even collaboration in some cases (Shaeffer, 1990).

Pedagogical Content Knowledge in Technology Education

In order to effectively teach a subject matter, the knowledge of the content and the pedagogy of that subject are of paramount significance for the teacher. Koehler and Mishra (2005) defined content as the subject matter that is learned or taught. For example, middle school physical science, undergraduate biology, 4th grade history are
contents that are different from one another. In science, according to the National Science Teachers Association (NSTA, 2003) standards for science teacher education, content includes the knowledge and skills that are learned or should be learned, in the course of the teacher’s science curriculum. Pedagogy, on the other hand, is the collected practice, processes, strategies, procedures, and methods of teaching and learning; it also includes knowledge about the aims of instruction, assessment, and student learning (Koehler & Mishra, 2005). Overall, knowing the content of the subject matter requires teachers to be able to make connections and see relationships between concepts and teach about the process, while knowing pedagogy of the subject matter calls for teachers to help students learn about those concepts.

Prior to the 1970s, content knowledge and pedagogy knowledge have been viewed separately in education. Researchers (Shulman, 1986; Ball & McDiarmid, 1990) mentioned that, historically, knowledge bases of teacher education have focused on the content knowledge of the teacher, and later teacher education has shifted its focus to pedagogy, often at the expense of content knowledge. Research on pedagogy has focused on the application of general pedagogical practices in the classroom, isolated from any relevant subject matter (Veal & Makinster, 1999).

In response to problems facing teaching and teacher education, Lee Shulman (1987) developed the construct of “pedagogical content knowledge” (PCK). Rather than viewing teacher education from the perspective of content or pedagogy, Shulman believed that teacher education programs should combine these two knowledge bases to
more effectively prepare teachers. According to him, PCK includes “the most useful forms of representation of (special attributes), the most analogies, illustrations, examples, explanations, and demonstrations – in a word, the ways of representing and formulating the subject that make it comprehensible to others (Shulman, 1987, p. 9). Moreover, Shulman asserted that PCK included those special attributes a teacher possessed that helped him/her guide a student to understand content in a manner that was personally meaningful. Shulman also mentioned that PCK consisted of “an understanding of how particular topics, problems, or issues are organized, presented, and adapted to diverse interests and abilities of learners, and presented for instruction” (p. 8). Finally, he argued that PCK was the best knowledge base of teaching:

The key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students (p. 15).

In short, PCK is about knowing what, when, why, and how to teach using a reservoir of knowledge of good teaching practice and experience. It is an accumulation of common elements, including knowledge of subject matter, knowledge of students and possible misconceptions, knowledge of curricula, and knowledge of general pedagogy.

Throughout the literature, only one study has been found dealing with the study of a PD program designed and implemented to enhance inservice teachers’ PCK in TE.
Indeed, in their study, Jones and Moreland (2004) portrayed the frameworks and cognitive tools that have been developed over a three-year period to enhance practicing teachers’ PCK in primary school TE. The research project emphasized the need for teachers to build a knowledge base for teaching TE. The increased PCK resulted in: enhanced teacher knowledge about technology including the nature of technology, areas of technology and specific technological knowledge, changed pedagogical approaches, enhanced teacher student interaction, refinement of appropriate learning outcomes, critical decision making, improved teacher confidence, and enhanced student learning. Finally, the authors presented seven characteristics or features of PCK they believed important for effective teaching and learning in TE. These features include:

- nature of technology and its characteristics;
- conceptual procedural and technical aspects of technology;
- knowledge of the relevant technology curriculum, including goals and objectives, as well as specific programs;
- knowledge of student learning in technology including existing technological knowledge, processes, strengths and weaknesses and progression of student learning;
- specific teaching and assessment practices of technology, e.g., authentic, holistic, construct reference;
- understanding the role and place of context in technological problem solving; and
- classroom environment and management in relation to technology, e.g. groupings, managing resources, equipment and technical management.
Science and Technology: Differences and Relationships

Based on their frames of reference, scholars differently define the terms science and technology. In addition, in the literature, both terms encompass a range of connotations. Consequently, according to some of the scholars, the differentiation between science and technology is clear, whereas others indicate that trying to find this distinction is not an easy task. In this section, attempts to define science and technology are presented; also the difference between both terms and their relationships are expounded. Instructional approaches related to teaching science and TE are also expounded.

Science

Science is one of the greatest achievements of human culture; it has revealed an enormous amount about ourselves and the world in which we live; and has directly and indirectly transformed the social and natural worlds (Matthews, 1994, p. xiv). According to Compton (2004), the purpose of science is to explain the natural world through iterative intellectual and investigative practices that involve observation and controlled manipulations of that world. Matthews and Compton’s descriptions of science illustrate the way many scholars portray science. Rather than providing an exact definition of science, they underline its purposes and its effects on people’s everyday life. On the other hand, there are diverse connotations presented by scholars based on their domain of expertise, their cultures, and in various historical times. “Science can mean organized knowledge about natural phenomena, or the thought processes which generate such
knowledge, or as a rubric of a set of disciplines; it can also refer to social systems and fields of work and study” (Gardner, 1994, p. 2).

Technology

According to Selby (1993), technology is the process and product of human skill and ingenuity in designing and making things out of available resources to satisfy personal and societal needs and wants. Pearson and Young (2002) provide a comprehensive definition of technology. They point out that, although technology is the process by which humans modify nature to meet their needs and wants, people still think only in terms of its artifacts, such as computers and software, aircraft, pesticides, water-treatment plant, birth-control, and microwave ovens. They go on to say:

Equally important aspects of technology are the knowledge and processes necessary to create and operate those products, such as engineering know-how and design, manufacturing expertise, various technical skills, and so on. Technology also includes all of the infrastructure necessary for the design, manufacture, operation, and repair of technological artifacts, from corporate headquarters and engineering schools to manufacturing plants and maintenance facilities. (p. 9)

Compton (2004) indicates that the purpose of technology is to intervene in the world to produce something ‘other’ than that which currently exists; it achieves this through iterative intellectual and design-based practices that involve multiple sources of input. Through these descriptions, it is obvious that (as with science) scholars attach
multiple connotations to technology. Gardner (1994) has collected these connotations indicating that technology “can refer to artifacts, or processes, or entire social systems, or fields of works, or fields of study” (p. 2). Also, Daumas (1976) shows that meanings of technology shift across languages. He points out that in English, the word technology embraces connotations, which in French are covered by two words, technique (organized knowledge and skill) and technologie (scientific technology).

Differences between Science and Technology

It is established that the distinction between both terms is not clear-cut. Some scholars hold the view that science and technology are indistinguishable, whereas others maintain that both terms are distinguishable. For those who adopt the indistinguishable view, it is no use to discuss science-technology relationships. They espouse the multiculturalism view stressing science and technology in non-Western cultures. They maintain that even in Western science, during the science fairs or in science museums, most of the exhibits deal with technology. Gardner (1994) noted that this view is actually a commonly held one emphasizing that for some people, the phrase science-technology rolls off the tongue as a single concept embracing anything to do with understanding and manipulating aspects of the world. Jones and Carr (1992) investigated teacher’s perceptions of technology education and reported that most of them hold that position affirming that technology is about science and goes along with science.
In order to explain their position, proponents of the distinguishable view of science and technology often focus upon the differing functions and outcomes of the two fields. Consequently, Benne and Birnbaum (1978) indicate that:

The aim of the scientist is to produce tested knowledge. The aim of the engineer or technologist is to transform knowledge into techniques and artifacts for which there is a human demand. Scientists operate within the domain of knowledge. Engineers and technologists operate within the domain of practice. (p. 13)

Many scholars maintain this distinction in purposes between both terms, especially those who believe that “science contributes to culture in ways that are not merely materialist or economic, and that the development of technological capability requires specific skills which are likely to be learned in science courses” (Gardner, 1994, p. 4). The supporters of the distinguishable view assert that the distinction is important if the accurate evaluation of the contributions of science and technology is to be performed, because the two are related, but neither synonymous nor identical. In that case, the question that arises is about their relationship.

Relationships between Science and Technology

Throughout the literature, there are polemics pertaining to the relationship between both terms. Indeed, among proponents of difference between science and technology, Gardner (1990) identifies four possible positions: science precedes technology, science and technology are independent, technology precedes science, and technology and science engage in two-way interaction.
The first position, science precedes technology, meaning technological capability grows out of scientific knowledge, is also called the technology applied science (TAS). This view, according to Ihde (1983), who disagrees with it, is the standard and dominant theory of the relationship between technology and science. Proponents of the TAS view emphasize the artifacts and systems that have followed scientific discoveries. They provide examples in old and modern times as well to support their view. The TAS view frequently finds expression in curriculum statements, instructional content and teachers’ opinions (Gardner, 1994). For example, Holman (1986) reported that a British guide for science teachers defines technology as “the enabling process by which science is applied to satisfy our needs” (p. 23). Gardner (1994) underlines that even though the TAS view can be defended on the grounds that it shows relevance of science to ‘real life’, it also has several consequences that are open to criticism.

The second position that stipulates that science and technology are independent is also called the demarcationist view, treating both terms as distinct fields, pursuing different goals, utilizing different methods, and carried out by different social groups. Indeed, proponents regarded science as analytic, concerned with generation of knowledge, advanced by scholars seeking understanding, and technology as synthetic, concerned with the production of things made by artisans driven by utilitarian motives. In order to support their arguments, proponents of the demarcationist view provide many examples. The historical independence of science and technology is rarely discussed
explicitly in school curricula, but the idea is implied in curricula in one field which largely ignore the other (Gardner, 1994).

The third position or materialist view is the reverse of the first position. It asserts that technology is historically and ontologically prior to science, that experience with tools, instruments and other artifacts is necessary for conceptual development. The materialist view is supported by at least three lines of argument: (1) humans have been making artifacts ever since our emergence as a distinct species; (2) the long list of specific cases of technological development preceding scientific understanding of it; and (3) technology is held to be necessary for generating scientific ideas. Examples are given for emphasizing each line of argument. Concerning the curriculum expression of this view, it is demonstrated that it is rarely articulated in science curriculum materials. However, some examples have been found in recent texts.

The fourth position, the interactionist view, considers scientists and technologists as groups of people who learn from each other in mutually beneficial ways. After tracing the birth and the evolution of both concepts, Selby (1993) argues that technology and science are partners, not relatives; they work together, yet they are fundamentally different. According to Selby, the roots of their current relationship lie in their separate development in the past. Compton (2004), a proponent of this view, highlights the effectiveness of the interaction of science and technology for students:

Scientific knowledge and methodologies themselves are useful, and in many cases critical, to students’ successful undertaking of technological practice and in the
development of technological knowledge. Technological knowledge, practices, and outcomes, in turn, can provide useful, and in many cases critical tools (both conceptual and material) for scientific practice and the development of scientific knowledge. Technological practices and outcomes can also provide authentic contexts which enable students to develop deeper understandings of scientific knowledge and methodologies (p. 3).

However, Compton advises the exploration of the nature of both concepts for a better understanding of the relationship between them.

Science and Technology Education: Instructional Approaches

The International Technology Education Association (ITEA) defined technology education as an educational program that helps people develop an understanding and competence in designing, producing, and using technology products and systems, and in assessing the appropriateness of technological actions. “It is the comprehensive curriculum area …concerned with technology, its evolution, utilization and significance;…its organization, personnel, systems, techniques, resources, and products; and their combined social and cultural impacts” (ITEA, 1985, p. 25). Because of technology education’s significance in students’ learning and its introduction into the science curriculum, scholars have been comparing various instructional approaches which have been used in teaching about technology and science. Gardner (1990) indicated that science textbooks analyses and research papers “reveal four approaches to the question of how to present instructional content on the relationship between
technology and science to learners” (p. 126). He provided a detail explanation of these four approaches.

Technology as illustration is the common approach to teaching about technology in science courses. In this approach, the teacher introduces a phenomenon (for example the reflection of light or the behavior of an electromagnet), presents relevant experiences (laboratory work, photographs, etc) and scientific principles, which are then illustrated by referring to technological application. This approach, which treats technology as applied science, is often found in school texts.

The second approach, which is the cognitive-motivational approach, also treats technology as applied science. However, this approach adopts a different rationale and sequence of presentation in an attempt to stimulate interest and understanding. The technological applications are introduced early in an instructional sequence in order to stimulate student interest and enhance meaningful learning of scientific concepts.

Technology as artifacts is the third approach, which involves studying artifacts to learn how they work, a kind of technological equivalent to anatomy and physiology. Artifacts are taken apart (either literally or intellectually) to study their parts, their function and how they inter-relate.

Finally, the last approach is the process approach. Technology is regarded a process of problem-solving inventing, designing, making; scientific ideas are relevant as they contribute to this. This last approach is favored in Benin’s New Study Programs.
Review of the Teaching Technology Education in Africa

Writing under the auspices of UNESCO, Faure et al. (1972) asserted “An understanding of technology is vital in the modern world, and must be part of everyone’s basic education. Lack of understanding of technological methods makes one more and more dependent on others in daily life…” (p. 66). The call for integrating TE in secondary school curriculum has gained remarkable support in most educational systems in developed countries, as well as in developing countries. Due to diverse challenges, many African countries have responded in various ways to the call.

Kerre (1990) indicated that in Africa, since the 1970s, the call has drawn particular interest from governments because of a lack of skilled levels workers to produce essential goods, high unemployment levels, despite greater demands for skilled labor, population expansion, and the increasing shift toward a more instrumental philosophy in education. Instead of calling for the integration of TE, he was advocating more the “vocationalization of school curricula.” He found that the curricula, the resources, and the implementation strategies are constraints impeding the integration of TE in school curricula in Africa. After stressing the three phases of conceptualizing the foundations and guidelines of the curricula advocated by UNESCO, he proposed the options and strategies to ingrain TE in Africa. Finally, he advised that for the 21st century, “Africa needs school curricula that is integrated, broad-based, and clearly articulated” (p. 43).
The pedagogical methodology for teaching TE in secondary school varies between and within countries. Williams (1992) pointed out that the design and problem solving methods encompass many advantages for less developed countries, especially African countries. In his study, after reviewing many articles, he found that the advantages include: (a) enhancement of self-concept by ensuring success; (b) provision of integrated learning environment; (c) development of initiative, responsibility, adaptability, self-reliance, and creativity; (d) pride in personal achievement; (e) development of problem solving as a learning strategy; and (f) promotion of self-sufficiency by giving the learner partial control over the learning environment. Because under the colonial system in African countries, a very low status was given to technical education, he claimed that utilization of the design methodology is particularly important and appropriate for these countries because “it affords a neat package for the marriage of the intellectual and physical skills” (p. 58), and “a design methodology, allied with appropriate technology problems and content, can be taught even in a resource-poor rural environment” (p. 57).

There is a lack of literature dealing with the overall state of integration of TE in school curriculum in African countries. However, a comparative analysis carried out by Ajeyalemi (1990) in seven English-speaking countries in Africa, establishes the extent to which TE is integrated and taught in these countries at the secondary school level. At the secondary level, it is “only in Nigeria and Ghana that an integrated course on technology education is a compulsory aspect of basic education at the junior classes” (p. 170). He
reported that, in both countries, the course includes basic principles of design and
elements of woodwork, metalwork, masonry, electronics and technical drawing. The
same courses are also available in the senior secondary classes. The main objective is for
all pupils to acquire basic pre-technical and pre-vocational skills. “In the other five
countries (Lesotho, Swaziland, Uganda, Zambia, and Zimbabwe), technical education is
available in special trade and technical schools, both in junior and senior classes” (p.
171). In other words, TE courses are not offered in these countries. He concluded that
whatever the type of course or curriculum content, TE or technical education at the
secondary level in all the seven countries still remains an under-developed relative to
academic secondary education.

A number of factors have been identified which have constituted serious barriers
to education generally and consequently to TE in developing countries (Ojo, 1996).
Indeed, throughout the literature, scholars (Pytlik, 1989; Akubue & Pytlik, 1990; Ojo,
1996; and Lewis, 2000) have established a list of problems impeding the integration of
TE in secondary school science curriculum, or its implementation in the case of its
integration in developing African countries. Concluding the comparative analysis, above-
mentioned, Ajelayemi (1990) carried out an inventory of issues in TE in Africa:

[Technology education] has neither been adequately funded nor effectively organized.
Suitably qualified teachers, teacher-trainers, instructional materials, workshops and
required equipment are in short supply. In addition to these problems
technical/technology education is viewed with disdain by society and, as such, it is
unpopular as a school subject. In all the countries, it is particularly unpopular among the female students. (p. 171)

On the other hand, using Nigeria as a case study, Ojo (1996) investigated some of the major barriers to integration of TE in secondary school. In addition to those listed by Ajelayemi, he found obstacles related to mass illiteracy, inadequate research and utilization of research data, and incessant political crises which he characterized as the mother of all barriers for most developing African countries. Finally, he indicated that, “technology education is highly critical to any meaningful and sustainable technological development and that the observed static and attenuated progress of technological development in developing African countries finds its root in lack of virile and well-implemented technology education in these countries” (p. 10).

Summary

Concept of teacher change, Bandura’s theory of self-efficacy, models of teacher PD, the concept of PCK in TE, science and technology including their differences, relationships and instructional approaches to teaching TE, and a review of the teaching of TE in Africa are the different sections comprising this chapter. Researchers’ views of teacher change and different models have been reviewed. The theory of self-efficacy introduced by Bandura and his theoretical framework related to the same topic are presented. Shulman’s concept of PCK in teaching is thoroughly expounded. The lack of literature related to PCK in TE is also raised. Finally, findings of research about models
of teacher PD in Western countries and sub-Saharan African countries, ways of
differentiating science and technology, and the teaching of TE in Africa are laid out.
CHAPTER III
METHODOLOGY

Introduction

Throughout the literature, many researchers (e.g., Compton & Jones, 1998; Stein, Gins, & McDonnalld, 2007; Jones, Mather, & Carr, 1995) investigated the outcomes of teacher professional development (PD) programs in technology education (TE). Even though some of these studies focused on secondary school teachers, none of them explored these teachers’ self-efficacy beliefs. The present study investigated the outcomes of a teacher PD in TE in secondary school settings in terms of teachers’ self-efficacy beliefs, teachers’ content knowledge in TE and teachers’ pedagogical content knowledge. Indeed, the practical purpose of the study was to provide Benin middle school science teachers with an effective technology education professional development (TEPD), and the research purpose of the study was to explore teachers’ content knowledge and pedagogical content knowledge and changes in teachers’ self-efficacy beliefs in teaching the TE part of the curriculum as a result of participating in the PD. The fundamental hypothesis of this study was that the participation of the Benin middle school science teachers in the TEPD program would result in the enhancement of their self-efficacy beliefs in teaching TE, their TE content knowledge and pedagogical content knowledge.

The present chapter deals with the methodology that was used in the study. It encompasses different sections such as (1) effective PD, (2) the setting and sampling
procedures, (3) the research design including the rationale for using the mixed methods research, (4) the data collection encompassing the instruments and procedures, (5) the quantitative data analysis, (6) the qualitative data analysis, and (7) the limitations and delimitations.

Effective Professional Development

Acknowledging the multiple characteristics of an effective PD identified by scholars (Loucks-Horsley et al., 2003; Guskey, 1986, Elmore, 2002), it was the researcher’s intention to provide teachers with an effective TEPD aligned with the New Study Programs’ requirements and tackling the shortcomings of past PD by addressing: (a) cultural and contextual issues; (b) expertise of the presenters; and (c) participating teachers’ TE content and pedagogical content knowledge.

In order to be effective, cultural and contextual issues were addressed during the implementation of the TEPD program. First, participation in a PD session in Benin does not provide teachers with Ministry certification, university credentials, career enhancement, or salary enhancement. While teachers are willing to attend and participate actively in a PD, they also expect some incentives for their efforts and for their time that they could otherwise have utilized for paid tutoring or for other businesses. Aware of these cultural and contextual issues, the researcher offered meals and refreshments during the TEPD sessions as partial compensations in order to encourage teachers’ full participation. Second, there is a high shortage of teachers in secondary schools in Benin and teachers are overloaded in order to cover as much content as possible. Consequently, to allow teachers’ involvement and interest, PD sessions were held only during spring
and Easter breaks. Finally, the lack of materials in most of the secondary schools in Benin constitutes a crucial problem. Teachers need tools to help them continue their own learning and to organize hands-on activities with students. Conscious of these contextual concerns, it was the researcher’s intention to equip teachers with necessary materials or, in the worse case scenario, to bestow teachers materials utilized during the PD sessions, in order to permit them to continue working with students.

Teachers, who attend trainings, funded either by the Ministry of Education or by Benin development partners, frequently question presenters’ knowledge and expertise. Due to his past experience as a former high school teacher and a pedagogic advisor in Benin, the researcher was conscious of teachers’ disappointment when imported experts unaware of Benin’s cultural and contextual issues provide PD for them. Consequently, the researcher and three knowledgeable presenters (the small working group), all native of Benin, from both high schools and vocational institutions, delivered the PD sessions.

Loucks-Horsley et al. (2003) recommend that “when teachers have learning experiences that help them understand how children best learn… they are better able to provide such experiences to their students” (p. 33). The PD, building on teachers’ knowledge in science, was designed to help them bridge the gap between science and TE. So, teachers have experienced what their students will be doing. For example, teachers learned the technological process and designed artifacts. Valli and Hawley (2002) suggested that “professional development should deal directly with what students are expected to learn and the instructional strategies best suited to teach that content” (p. 87).
Therefore, teachers learned the process of designing and making technological artifacts, as well as problem solving steps in TE specified in the New Study Programs.

Setting and Sampling Procedures

Setting

The study took place in the Republic of Benin. This context is particularly crucial to the study because, the researcher would like to provide Benin’s middle school science teachers with pedagogical tools for teaching TE to students, and to provide secondary (middle and high school) inspectors with some research-based information for the understanding of an effective implementation of a PD. The study was completed in the capital city Porto-Novo, located in the southern region of the country. The choice of the capital city was deliberate due to the presence in that city of the Ministry of Primary and Secondary Education, major educational institutions, and curriculum reform headquarters.

Sampling Procedures

Two groups of middle school science teachers participated in the study. The first group of twenty three \(N = 23\) teachers, contacted directly by the researcher, took part in the four TEPD sessions implemented on 2/19/08, 2/22/08, 3/25/08, and 3/27/08; whereas, the second group of twenty eight \(N = 28\) teachers were contacted by their principals through an administrative letter sent by the director of the National Institute of Research and Training in Education (INFRE), where the researcher was doing an internship. Members of the second group participated in the same four sessions of PD on 3/28/08, 4/1/08, 4/4/08, and 4/7/08. Therefore, in total, fifty-one \(N = 51\) middle school science
teachers in the capital city participated in the study. It is important to note that participating teachers are teaching in the public secondary schools and private schools as well. Even though both groups participated at different times in the sessions, there is no doubt that both groups are identical. Context data and other background information support this assertion. First, the participants came from the population of secondary schools physical science teachers. Second, they are teaching the same subject matter at the premier cycle (6-9 graders) in secondary schools in the capital city. Third, descriptive statistics for the participants indicated that 98 % of the participants were male and only 2 % were female. Fourth, data related to teachers’ years of professional experience shows that almost all participants are at the beginning of their profession as indicated in Table 1.

Table 1

*Years of Professional Experience in Teaching (N = 51)*

<table>
<thead>
<tr>
<th>Category of Years</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 5</td>
<td>10</td>
</tr>
<tr>
<td>6 to 10</td>
<td>9</td>
</tr>
<tr>
<td>11 to 15</td>
<td>1</td>
</tr>
<tr>
<td>16 to 20</td>
<td>2</td>
</tr>
<tr>
<td>20+</td>
<td>1</td>
</tr>
</tbody>
</table>

Group 1

<table>
<thead>
<tr>
<th>1 to 5</th>
<th>39.13 %</th>
<th>4.34 %</th>
<th>8.7 %</th>
<th>4.34 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 2</td>
<td>16</td>
<td>6</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Percentage</td>
<td>57.14 %</td>
<td>21.43 %</td>
<td>10.71 %</td>
<td>7.14 %</td>
</tr>
</tbody>
</table>

Fifth, both groups’ members have the same teaching background. Finally, they have been trained in the same conditions, meaning same schedules for the same activities. The only difference between them is that participants of the first accepted willingly to participate, while the second group’s participants were encouraged to take part. This number of participating teachers was the researcher’s proposed number of teachers due to financial
reasons. In fact, the literature (Shaeffer, 1990; Gidey, 2002; Guskey, 2000; Kelleher, 2003) shows that implementing a PD with teachers requires funds to pay for teachers’ per diem, meals, and other related costs, such as the materials for the training, and instructors’ stipend. Therefore, in the scope of this research study, because of lack of financial resources, the number of participants has been maintained at fifty.

Content of the Professional Development Program

Salpeter (2003) pointed out that “face-to-face presentations, some of them including hands-on lab sessions, are still at the core of most professional development programs involving technology” (p. 34). Similarly, the TEPD program encompassed two different parts: a theoretical part and a practical part. The PD activities were fundamentally based on Shaeffer’s (1990) five characteristics described earlier. Teachers were required to “participate” and not just “attend” the PD sessions. Even though there were some lectures followed by questions and discussions, participating teachers were thoroughly involved during the practical process. The researcher, assisted by the small working group, presented the theoretical part. Table 2 presents the content of the TEPD program.
Table 2

**TEPD Topics by Session**

<table>
<thead>
<tr>
<th>Session</th>
<th>Activities</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>Administration of instruments as pretest</td>
<td>Daily journal to be completed for next session</td>
</tr>
<tr>
<td></td>
<td>Lecture and discussion: Science and technology: Differences and Relations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Designing and making artifacts: Electrolysis apparatus and Electrical current detector</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research on the Internet in cybercafés</td>
<td></td>
</tr>
<tr>
<td>Two</td>
<td>Lecture and discussion: Why Teach Technology and Technology Education</td>
<td>Daily journal to be completed for next session</td>
</tr>
<tr>
<td></td>
<td>Designing and making artifacts: Acoustic instrument: Guitar and Drum</td>
<td></td>
</tr>
<tr>
<td>Three</td>
<td>Lecture and discussion: Technological Pedagogical Content Knowledge</td>
<td>Daily journal to be completed for next session</td>
</tr>
<tr>
<td></td>
<td>Designing and making artifacts: Liquid thermometer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research on the Internet in cybercafés</td>
<td></td>
</tr>
<tr>
<td>Four</td>
<td>Lecture and discussion: Evaluation of students’ artifacts</td>
<td>Daily journal to be completed in class</td>
</tr>
<tr>
<td></td>
<td>Designing and making artifacts: Review of artifacts made</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluation of one of the artifacts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Administration of instruments as posttest</td>
<td></td>
</tr>
</tbody>
</table>

The researcher, aided by the vocational school teacher, presented the practical part of the PD sessions. Teachers, throughout the technological processes, designed many
artifacts with the materials provided by the researcher. The practical part of the training was “self-directed and teacher self-taught” (Shaeffer, 1990), as the researcher and the vocational teacher encouraged the participants to take control of the learning. Also, as stressed by Shaeffer (1990), teachers observed their peers, analyzed their own experiences, and learned from each other. The overall role of the researcher and the vocational teacher was a moderator role. Finally, throughout the PD program, participating teachers and the team of trainers designed rubrics to assess teachers’ works.

In order to be able to prepare for his responsibilities and to get acquainted with the practical activities, the researcher, prior to conducting his research, observed classes and worked in workshops (woodwork, construction, metalwork, and foundry, etc.) at the College of Technology at Kent State University.

The two groups of teachers attended the PD sessions implemented during spring and Easter breaks in two high schools of the capital city, made available with no charge by the principals who understood that the sessions were to train secondary school science teachers in TE. Table 3 presents the sequences of activities of a session.
Table 3

Sequences of Activities of a Session

<table>
<thead>
<tr>
<th>Hour</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 – 10:00</td>
<td>Lecture and discussion</td>
</tr>
<tr>
<td>10:00 – 10:15</td>
<td>Refreshments and Coffees</td>
</tr>
<tr>
<td>10:15 – 12:00</td>
<td>Designing and making artifacts</td>
</tr>
<tr>
<td>12:00 – 1:00</td>
<td>Lunch and networking</td>
</tr>
<tr>
<td>1:00 – 2:30</td>
<td>Designing and making artifacts</td>
</tr>
<tr>
<td>2:30 – 3:00</td>
<td>Daily evaluation</td>
</tr>
</tbody>
</table>

The two sessions of research on the Internet were implemented after 3:00 PM in a cybercafé. Indeed, as computers are not available in every school in Benin, teachers were given the opportunity to search for TE-related information online through the Internet. Finally, during the implementation of the TEPD sessions, teachers’ photographs were taken in order to document the whole process.

Research Design

Methodology

A mixed methods research design (Creswell, 2002), combining qualitative data, and quantitative data, was utilized to provide a fuller understanding of participants’ responses (Bogdan & Biklen, 1998; Patton, 2002). Both qualitative and quantitative data were collected over the spring 2008 semester from the beginning to the end of the project. Quantitative research methods were used to explore changes in teachers’ self-efficacy.
beliefs and the mastery of teachers’ content knowledge in TE. A qualitative naturalistic approach (Guba & Lincoln, 1994) was used to investigate teachers’ mastery of pedagogical content knowledge and their perceptions of the PD activities. Also, the students’ understanding of the materials taught was assessed using teacher-designed rubrics and open-ended interviews.

**Rationale for Using a Mixed Methods Design**

Mixed methods research is defined as “the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study” (Johnson & Onwuegbuzie, 2004, p. 12). Quantitative and qualitative researchers acknowledged the soundness of mixed methods research. Researchers are turning to mixed methods to conduct stronger research (Rocco, et al., 2003), because they have increasingly accepted the underlying assumption that biases are inherent in any one particular method of data collection or analysis. Moreover, White (2007) mentioned, “The goal of mixed methods research is not to replace either of [qualitative and quantitative] approaches but rather to draw from the strengths and minimize the weaknesses of both in a single research study and across related studies” (p. 4).

There are many ways of mixing methods and many levels of mixing both qualitative and quantitative elements in research projects. Greene, Caracelli, and Graham (1989) reviewed 57 mixed methods studies and identified five purposes for adopting mixed methods design strategies: triangulation, complementarily, development, initiation, and expansion. Triangulation increases a study’s validity; it “evolved to include using
multiple data collection and analysis methods, multiple data sources, multiples analysts, and multiple theories and perspectives” (Patton, 2002). To increase a study’s validity and interpretability, complementarily measures “overlapping, but also different facets of a phenomenon” (Greene, et al., 1989, p. 258). Greene et al. indicated that to increase a study’s validity, development uses the “results from one method to help develop or inform the other method” (p. 259). To add depth and breadth to inquiry results and interpretations, initiation uses the intentional analysis of inconsistent qualitative and quantitative findings. Finally, to widen the scope of inquiry, expansion calls for including multiple components to “extend the breadth and range of the study” (p. 259).

The use of a mixed methods design in this study pertains to its purposes of triangulation and expansion. Triangulation was one of this research mixed methods design purposes because of the researcher’s desire to increase the study’s validity. It is the researcher’s intention to use quantitative questionnaires and the qualitative interviews to assess participants’ self-efficacy beliefs and their perceptions on the implementation and the impacts of the TEPD program on the participating teachers. Denzin (1989) advised, “By combining multiple observers, theories, methods, and data sources, [researchers] can hope to overcome the intrinsic bias that comes from single-methods, single-observer, and single theory studies” (p. 307).

Expansion was the second purpose for using mixed methods research in this study, because the researcher expects to broaden the scope of the study. Therefore, while the quantitative method was used to assess the program outcomes, the qualitative method would be utilized to assess the TEPD program processes. However, the research followed
the three stages of a mixed methods research developed by Tashakkori and Teddlie (1998). The first stage was the confirmatory stage as the researcher’s intention was to corroborate his research hypotheses; the second stage concerned the type of data collection and other operations; and finally, the third stage concerned the type of data analysis and inference. Overall, the study consisted of a confirmatory investigation, because the quantitative data was collected in the first place, followed by the qualitative data collection and statistical analysis.

There are two paradigmatic positions within the mixed methods research tradition, which are the pragmatist position (e.g. Patton, 1988; Reichardt & Cook, 1979; Reichardt & Rallis, 1994; Tashakkori & Teddlie, 1998) and the dialectical position (e.g. Greene & Caracelli, 1997; Kidder & Fine, 1987; Maxwell & Loomis, 2003). Rocco et al. (2003) advanced that the underlying assumption for the dialectical position is that research is stronger when it mixes research paradigms, because a fuller understanding of human phenomena is gained. Dialectical researchers believe it is more ethical to mix methods “in order to represent a plurality of interests, voices, and perspectives” (Greene & Caracelli, 1997, p. 14). The researcher claims the pragmatist position, which calls for using “whatever philosophical and/or methodological approach works for the particular research problem under study” (Tashakkori & Teddlie, 1998, p. 5). Research design and implementation decisions are made according to which methods best meet the practical demands of a particular inquiry (Patton, 1988). Rocco et al. (2003) argued that in that position, “The researcher holds no a priori commitment to using mixed methods; all are
compatible and potentially useful. Mixing may occur in a particular study if the researcher decides it will help make the data collection more useful” (p. 21).

Methodological Precautions

As above-mentioned, the researcher’s pragmatic position for the mixed methods tradition and a combination of triangulation and expansion pertained to ensure the credibility and validity of data collection and findings of the study. Also, the following precautions were taken to ensure good data collection conditions: 1) Contact with Benin education officials; 2) Contact with secondary school science teachers; 3) Internship at the INFRE; and 4) Small Working Group.

Contact with Benin Education Officials

Since the practical purpose of the study was to work with secondary school physical science teachers during the school year and perform classroom observations, the researcher contacted Benin education officials before starting his investigation, in order to inform them about the entire research project. He then received written authorization from the Ministry of Primary and Secondary Education (MPSE) and from the Institut National pour la Formation et la Recherche en Education (INFRE) [National Institute of Training and Educational Research], allowing him to perform the TEPD sessions with teachers. Also, he met with some high school principals to make arrangement to carry out the training in their school and/or to perform classroom observations.

Contact with Secondary School Science Teachers

Taking advantage of a PD sponsored by the MPSE in the province of Ouémé, the researcher met with secondary school science teachers, explained the essence of his
study, and solicited their participation. These teachers constituted the first group of participants. Due to the defection of many teachers who had registered, the researcher talked to educational authorities of the above-mentioned institutions. Letters were then sent to encourage other teachers to get involved in the PD sessions, and also to the headmasters (principals) of the schools to inform them about the project and to seek their full collaboration.

*Internship at the INFRE*

The Director of the INFRE granted the researcher a six-month internship at the institute. This strategic internship position facilitated access to educational policy makers, teachers, official documents such as educational research reports, and curricular materials. During that period of internship and data collection, the researcher participated in various workshops, conferences, and trainings with other secondary school teachers.

*Small Working Group*

For the purpose of the study, three ($N = 3$) teachers – two physical science teachers and pedagogic advisors and one TE teacher from a vocational institution – were selected to constitute the small working group. The sampling protocol of these teachers followed a procedure called “reputational-case sampling” (McMillan & Schumacher, 1997); the procedure consists of obtaining the recommendation of knowledgeable experts in the selection of “competent and appropriate” participants who are “good” teachers. In addition, this selection was based on teachers’ interest in teaching TE. The overall task of this small group of teachers was to assist the researcher during the TEPD sessions and during class observations, and to provide feedback to the observed teacher. At the
beginning of the TEPD sessions, each member of the small working group released a signed written consent form (refer to Appendix A).

Data Collection

This section comprises an overview of the content of the PD program, the quantitative data collection and the qualitative data collection. The quantitative data collection deals with the design of the instruments used and the procedures for administering the instruments. The qualitative data collection includes other processes that were utilized to answer the qualitative research questions.

The two first research questions were quantitative in nature. The first question was to investigate the effect of the TEPD program on teachers’ self-efficacy beliefs. The second quantitative question was to explore the outcome of the program on teachers’ understanding of TE content knowledge.

For reasons provided in the rationale for using mixed methods section, three qualitative research questions are posed in this study to support the findings of the two quantitative research questions. The third research question dealing with teachers’ pedagogical content knowledge was investigated through class observations using class observation rubrics, tape-recorded teachers’ interviews, students’ open-ended interviews and pictures of students’ artifacts. The fourth question coping with the extent to which teachers are teaching the TE lessons in their classroom was examined through class observations, teachers and students’ open-ended interviews, and pictures of students’ artifacts. Finally, the answer to the fifth question pertaining to how they perceive their
own TEPD experiences was based on teachers’ interviews, their after-session journals, and their post-session evaluations.

**Quantitative Data Collection**

Quantitative data were collected using two important instruments. The technology education teaching efficacy belief instrument (TETEBI) adapted from STEBI- form A (Riggs and Enochs, 1990) was used to investigate teachers’ self-efficacy beliefs in TE and the technology education awareness instrument (TE Awareness) was utilized to explore teachers’ content knowledge mastery in TE.

**The TETEBI Instrument**

As stated earlier, the present research study is of a unique nature. No researcher has so far conducted a quantitative investigation in TE teachers’ self-efficacy beliefs. However, much has been done on teachers’ self-efficacy in teaching science, mathematics, computer use, and the use of Internet by means of different instruments.

Similar to STEBI-CHEM, MTEBI and PITEBS, the instrument for this study is called the technology education teaching efficacy belief instrument (TETEBI) (refer to Appendix B) was also adapted from STEBI- form A. Few changes were made in the original STEBI. Indeed, “technology education” replaced “science” throughout the original text and in statement 3, “chapters” replaced “subjects.” The adapted instrument encompasses 25 items in the Likert scale format and each item has five response categories: *strongly agree*, *agree*, *uncertain*, *disagree*, and *strongly disagree*. The TETEBI consists of two subscales consistent with the theory suggested by Bandura (1977) and applied to teaching by Gibson and Dembo (1984), that the researcher named
personal technology education teaching efficacy belief (PTETEB) and technology education teaching outcome expectancy (TETOE). The reason for favoring this instrument is twofold. First, it is preferred because, like STEBI, it provides a measure for TE teaching self-efficacy and outcome expectancy. Second, it is preferred for this research study because, “it is more consistent with Bandura’s theoretical hypothesis that the most complete prediction of human behavior can be derived by independent and interdependent knowledge of both the self-efficacy and outcome expectancy variables” (Enochs, Scharmann, & Riggs, 1995, p. 67). For the current study, reliability of the two scales of the TETEBI instrument was run. The TETOE has a coefficient alpha reliability of .631 and .379 for the PTETEB. The TETOE scale reliability is reasonable for assuming that the instrument is reliable for the present study, but the PTETEB scale reliability is very low. This low reliability coefficient might be due to the small size of the sample.

**Technology Education Awareness Instrument**

The researcher designed the TE Awareness instrument (refer to Appendix C) to check teachers’ mastery in TE content knowledge. It encompasses twenty-three true or false statements grouped into the three following sections: (1) science and technology; (2) technology; and (3) technology education. Science and technology section comprises nine statements related to the relationship and the differences between both concepts. For example, one of the statements in this section is “There is interaction between science and technology.” Technology section consists of eight statements dealing with the definition of technology and its impact on people’s lives. One representative statement in
this part is: “Technology mainly concerns computers and similar equipment.”

Technology education section is made of six statements concerning its significance and objectives in school curricula. “The technological process of design stimulates the learner to conceive, evaluate, and to re-conceive solution to problems” is one of the statements in the TE part of the instrument. Reliability of the three scales of the TE Awareness was run. Science and technology scale has a coefficient alpha of .291, technology scale has a coefficient alpha of .364, and .491 for technology education scale. At least three arguments could be put forward to explain these low alpha coefficients. First and most importantly, Cronbach’s alpha depends on the number of items within each scale. This coefficient increases when the number of items increases. In this present instrument, science and technology scale has nine items, technology scale has eight, and technology education scale has only six. Second, the items in the scales were not measured on the Likert’s scale, but on “true” or “false” scale. This fact could probably impact the alpha coefficients of the different scales. Finally, the small size of the sample could also explain the low alpha coefficients observed for the TE Awareness instrument different scales.

Administration of the Instruments

The quantitative research design that was used to answer the first two research questions is a pre-experimental one-group pretest-posttest research design to establish relationship between the outcomes of interest (TETEBI and TE Awareness) and an intervention (participation in the TEPD program). In the scope of the study, the researcher administered the TETEBI and the TE Awareness instruments to the participating teachers prior to the four sessions of the PD. It is important to note that
before taking the two questionnaires, each of the participating teachers released a signed written consent form (refer to Appendix D). At the end of the last session, these teachers once again received both instruments as a posttest. For the TE Awareness, the independent variable constitutes the knowledge before and after participating in the PD and exposed by its content and its related activities, whereas the dependent variable is the score received by each teacher.

Translation of the Instruments

Translation and back-translation (Brislin, 1970) techniques were used to translate both instruments. Many researchers (e.g., Ahyoung & Eun-Young, 1999) utilized the back-translation procedure and acknowledged its effectiveness in cross-cultural translations. The research setting being a French-speaking country, two bilinguals were employed. The first – a native French-African instructor and professional translator and graduate of Kent State University’s Modern and Classical Languages Studies Translation Department – translated the two instruments from the source (English) to the target language (French), the second - an African literature professor from Benin teaching at college level in Connecticut – blindly translated both back from the target to the source. Then, comparing the two versions of the two instruments, the researcher noticed that they were identical.

Qualitative Data Collection

After-Session Journals

At the end of each PD session, participating teachers were required to write a journal that they turned in to the researcher at the beginning of the following session.
After-session journals questions (refer to Appendix E) were designed to collect information about participants’ perceptions and allow them to talk about their feelings, learning and awareness of the TEPD program. According to Jones, Mather, and Carr (1995), PD in the area of technology should include reflection on one’s own, and others’ conceptions of technology, pedagogical knowledge, and technological practices. Also, in Shaeffer’s (1990) framework of participatory teacher training, reflection and introspection are of paramount significance. Therefore, teachers were asked to reflect about the PD session, the teaching of the notions of TE learned, and the impact of this teaching on students’ achievement. Following are some of the questions that were asked to teachers:

- Reflecting over the whole *New Study Programs* and the technology education (TE) portion in the science curriculum, do you think that teaching TE is important to students? If yes, why? If not, why not?

- What did you find the most useful in the TEPD session this session?

- Do the TEPD sessions help you understand TE content knowledge and how to teach it? Please explain.

- Did the present workshop meet your expectations? Please explain.

*Post-Session Evaluation*

After each session, teachers received a post-session evaluation or a daily evaluation (refer to Appendix F). On a form provided, teachers responded to the following questions: What did I learn today? What was the best part of today’s class? What question do you have about today’s topic? Other comments?
Class Observations and Interviews

Class Observations

Due to teachers’ strikes in the country, only few classroom observations were performed. For the same reason, class observations started after the delivery of the whole TEPD program. Agar (1996) indicated that participant observation represents the assumption that the raw material of field-based research lies in people’s activities, and the best way to access those activities is to establish relationships with those people, participate to some degree in what they do, and observe what is going on. In total, the researcher aided by the small working group completed four class observations at some school sites of two teachers in each of the two groups of teachers. The teacher being observed taught an hour-long class related to a section of what was learned during the TEPD program. He related the object to be made to a specific concept in physics, and then organized his students in small groups of five or six to design and make the artifact following technological processes and using everyday recyclable materials. During classroom observations, the researcher and the small working group members scored the observed teacher using the TE classroom observation instrument. Also, they engaged in passive observation, before moving up to moderate participation while interacting with students. After class observation, the small group members provided a contextual background and a brief description of activities, which occurred in the classroom. Finally, during class observations, photographs of students’ artifacts were taken in order to check their teachers’ evaluation skills using rubrics designed during the PD sessions.
Technology Education Classroom Observation Instrument

Classroom observations were performed using the technology education classroom observation instrument in use in Benin education (refer to Appendix G). This instrument was preferred for this study for two reasons. First, it was designed by Benin educational leaders and second, it took into consideration Benin cultural context. The instrument is comprised of two parts. The first part deals with general background information (school name, teacher’s name, observer’s name, grade level, start time, end time, etc.). The second part encompasses the rubrics of the observation, made of 26 questions. Five questions deal with the general state of the classroom (ventilation and lighting of the class, furniture in the class, grouping of the students) and 21 questions with teacher’s activities in the classroom. At the time of the observation, questions are answered by the observer using the following scale: 1 = very well or yes; 2 = well or sufficiently well; 3 = well enough or sufficiently; 4 = unacceptable; 5 = null or no.

Open-ended Interviews with Students

The researcher conducted a fifteen-minute tape-recorded interview after each class observation with 4 or 5 randomly selected students, to investigate their understanding of the process of making artifacts. These students, after releasing a signed written consent form (refer to Appendix H) answered questions such as: (1) what are the different technological steps of making artifacts? (2) What types of difficulties have you encountered while making or repairing the products? Why did you choose this type of material for your products? (3) Could you relate what you learn in your TE class to your everyday life? The interviews were open-ended in nature, as the interviewees were
permitted “to take whatever direction and use whatever words they want in order to represent what they have to say” (Patton, 1990, p. 297).

**Interviews with Teachers**

Teachers’ interviews were important in the process of data collection. Bogdan and Biklen (2007) recommend that interviews may be employed in conjunction with participant observation. Therefore, after students’ interviews, the researcher, along with the small working group met, with the observed teacher for a thirty-minute tape-recorded discussion. The latter, after releasing a signed written consent form (refer to Appendix H), was asked to reflect on his teaching, on his students’ learning of the TE lesson, and to assess the quality of students’ artifacts. He was asked to state what went well during the lesson, and what he could improve, if given a chance to teach again the same topic. The interviews were open-ended; therefore, there was no interview protocol.

**Quantitative Data Analysis**

The data from the pretest-posttest with the TETBI and the TE Awareness instrument were analyzed using quantitative procedures. For the purpose of testing the hypotheses of the two first questions, a variety of quantitative measures, such as descriptive statistics (means and standard deviation) of the key sample characteristics, dependent samples t-test comparing the means of the pretest and posttest, and Pearson correlation were conducted. The Statistical Package for the Social Sciences, SPSS 15.0 for Windows 2003, was utilized for quantitative data analysis.
Qualitative Data Analysis

Data analysis represents “the process of systematically searching and arranging the interview transcripts, fieldnotes, and other materials” (Bogdan & Biklen, 2007 p. 159) accumulated to enable the researcher to come up with findings. The analysis of qualitative data followed a procedure recommended by Miles and Huberman (1994). Students’ and teachers’ open-ended interviews were transcribed. The transcriptions previously in French were translated in English using back-translation (Brislin, 1970) techniques. Taking into account the research questions, the researcher read many times the qualitative data, including transcriptions of students’ and teachers’ open-ended interviews, teachers’ after-session journals, teachers’ post-session evaluations, and feedback from teachers and the small working group members. He identified many themes that he coded and categorized. He also checked these themes for representativeness.

Limitations and Delimitations of the Study

Limitations of the Study

Major limitations of the study include the design of the instruments (the TETEBI and the TE Awareness instrument), the time restriction for class observations, the sampling procedure and the sample size of participants, the delivery of the TEPD program and other threats pertaining to internal validity of pre-experimental designs.

One of the limitations of the study is related to the TETEBI used and the TE Awareness instrument designed by the researcher. The reliability coefficients of the different scales within the instruments were very low. However, the argument in favor of
the TETEBI instrument is that it has been adapted from the STEBI instrument used by many researchers, which has a high coefficient alpha reliability and whose validity has been tested. On the other hand, the content of the TE Awareness instrument is related to the content of the PD program.

Due to the duration of the data collection and other problems encountered while collecting data, such as teachers’ strikes during the school year, the number of classroom observations was limited to four. Therefore, time restriction was also a limitation of the study. It would have been interesting to visit as many teachers as possible to gather enough information.

Another limitation of the study was the sampling procedure of participants. Even though the pre-experimental research design deals with an intact group of participants, it would have been interesting to perform the sampling of middle grade school science teachers from the whole population of teachers in the country. In the present case, no participants sampling was performed; moreover, only teachers in the capital city were asked to participate in the study because of the limited time at the disposal of the researcher and the funding issues. In addition to the sampling procedure, it is important to note that the sample size of participants was small to provide significant results on the outcomes.

The number of TEPD sessions was limited to four because of teachers’ defection and the decreasing number of participants during the delivery of the TEPD sessions. Teachers failed to attend the sessions en masse and the researcher noticed that their original number was decreasing throughout the span of the TEPD program.
Consequently, delivering four sessions instead of six as proposed was a limitation of the study.

A key limitation of the study is the pre-experimental research design. This type of research design is the least preferred in the experimental research designs. Indeed, in the pre-experimental research designs, it is impossible for the researcher to “ensure that a change in the value of the independent variable is accompanied by a change in the value of the dependent variable, which is one of the key requirements for asserting that a causal relationship exists between two variables” (Martella, Nelson, and Marchand-Martella, 1999, p. 153).

One more limitation is related to the administration of the test. The testing issue is a real limitation in the experimental research designs. Because the pretest and the posttest are alike, participating teachers might want to improve their score on the second test, and then impact the study outcomes.

**Delimitations of the Study**

The delimitation of the study deals with many issues raised in the limitations of the study session, because it is well known in the quantitative research that when an issue is raised as a limitation of a study, it always opens up a delimitation issue. In that respect, one of the delimitations of the study is related to the generalization across participants. Indeed, the way the sampling of the participants was performed limits “the generalization from the study participants to the accessible population” of middle school science teachers in the country. Moreover, the fact that the TEPD program has been delivered to two groups of teachers instead of one could be considered as delimitation. However, due
to the centralized nature of the education system and the *New Study Programs* in Benin, the findings of the study would provide an overall schema and diagnostic data to program developers.

A delimitation of the study was “the verification of the independent variable.” The PD designed is an effective one and the researcher tried to implement it at his best. However, based on unforeseen situations, some teachers were not able to attend all four sessions of the TEPD. This issue could impact the outcomes of the study.

A last delimitation of the study is related to the experimenter effects. These effects are also referred to as “generalization across behavior change agents” (Martella, et al., 1999). Indeed, the findings of the study might be different if the PD was implemented with teachers in other areas of the country. In this case, the generalization of the study to other teachers could be problematic.

**Summary**

This chapter provided the reader with the different processes to conduct the entire study. The setting and sampling procedures, the research design, the data collection instruments and procedures, the quantitative data analysis, the qualitative data analysis, and the limitations and delimitations of the study are thoroughly expounded. Due to the unique nature of the study, the researcher designed his instrument, the TETEBI, which is adapted from the STEBI used in science teaching. Finally, the generalization of the study findings would be difficult due to some limitations.
CHAPTER IV
DATA ANALYSIS AND RESULTS

The preceding three chapters presented the background and the purpose of the study, the theoretical framework of the design, the review of literature, and the research methodology. The substance of this chapter deals with the analysis of the data collected and the results of analysis. Both quantitative and qualitative data analysis and their results will be provided.

Characteristics of the Two Groups of Teachers

A series of statistical analyses were run to isolate the effect of teaching experience and the effect of the two groups of teachers (the first group comprised volunteer teachers and the second group comprised teachers requested through a letter from the Ministry of education) on the outcomes of the study. Results of the two instruments’ (TETEBI and TE Awareness) subscales were taken into consideration.

Years of Teaching Experience

Teachers of both groups were asked to report their years of science teaching experience in secondary school, which was treated as a categorical variable in the analysis. Results suggested that the effect of years of teaching experience on teachers’ technology education (TE) self-efficacy was not statistically significant among subjects, $F(1, 37) = 1.163, p = .288$. This finding is consistent for both pre and post-tests for the technology education teacher efficacy beliefs instrument (TETEBI), $F = .080, p = .779$. 
Overall, year of teaching experience was not a confounding variable for the outcomes of the study.

*The TETEBI Test*

*Outcome Expectancy by Group*

Both groups of teachers were tested on the outcome expectancy. Results suggested that there was no significant difference between the two groups on the outcome expectancy, $F(1, 39) = .493, p = .487$. This finding is consistent for both pre and post tests, $F(1, 39) = 1.6, p = .213$. On average, the two groups of teachers did not show a significant improvement in the outcome expectancy before and after participating in the PD, $F(1, 39) = .251, p = .619$.

Table 4

*Descriptive Statistics for the Outcome Expectancy*

<table>
<thead>
<tr>
<th>Group</th>
<th>Time</th>
<th>$M$</th>
<th>$SD$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre</td>
<td>43.706</td>
<td>5.554</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>45.824</td>
<td>4.202</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>Pre</td>
<td>44.375</td>
<td>6.697</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>43.458</td>
<td>4.384</td>
<td>24</td>
</tr>
</tbody>
</table>
Figure 2. Outcome expectancy by group.

Figure 2 showed that, over time, outcome expectancy increased for members of group 1 ($M_{pre} = 43.706; M_{post} = 45.824$), whereas, it did not increase for members of group 2 ($M_{pre} = 44.375; M_{post} = 43.458$). However, the differences are minimal when expressed in terms of standard deviations. These differences represent the effect size, which is the difference between the two means divided by the pooled standard deviation, $ES = .43$.

**Personal Teaching Efficacy by Group**

Both groups of teachers were tested on the personal teaching efficacy. Results suggested that there was no significant difference between the two groups on the personal teaching efficacy outcome, $F (1, 38) = .196, p = .661$. This finding is consistent for both
pre and post tests, $F (1, 38) = 1.335, p = .255$. On average, the two groups of teachers did not show significant improvement on the personal teaching efficacy before and after participating in the PD, $F (1, 38) = 1.362, p = .551$.

Table 5

*Descriptive Analysis for the Personal Teaching Efficacy*

<table>
<thead>
<tr>
<th>Group</th>
<th>Time</th>
<th>$M$</th>
<th>$SD$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre</td>
<td>38.563</td>
<td>6.723</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>40.813</td>
<td>5.612</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Pre</td>
<td>40.583</td>
<td>5.695</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>39.875</td>
<td>4.132</td>
<td>24</td>
</tr>
</tbody>
</table>
Figure 3 showed that, over time, personal teaching efficacy was enhanced for members of group 1 ($M_{pre} = 38.563; M_{post} = 40.813$), whereas, for the same scale, the program did not impact members of group 2 ($M_{pre} = 40.583; M_{post} = 39.875$). However, the differences are minimal when expressed in terms of standard deviations, $ES = .43$.

**Overall Teacher Self-Efficacy by group**

Both groups of teachers were tested on the teacher self-efficacy (combining both scales) outcome. Results suggested that there was no significant difference between the two groups on the teacher self-efficacy outcome, $F(1, 38) = .42, p = .839$. This finding is consistent for both pre and post tests, $F(1, 38) = 1.439, p = .238$. On average, both
groups of teachers did not show significant improvement in the teacher self-efficacy before and after participating in the PD, $F (1, 38) = .041, p = .840$.

Table 6

*Descriptive Analysis for the Teacher Self-efficacy*

<table>
<thead>
<tr>
<th>Group</th>
<th>Time</th>
<th>$M$</th>
<th>$SD$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre</td>
<td>82.063</td>
<td>11.150</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>84.938</td>
<td>7.611</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Pre</td>
<td>84.958</td>
<td>10.490</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>82.917</td>
<td>6.984</td>
<td>24</td>
</tr>
</tbody>
</table>
Figure 4 showed that group 1 members’ self-efficacy enhanced over time ($M_{pre} = 82.063; M_{post} = 84.938$), whereas, over time, the program did not impact group 2 members’ self-efficacy ($M_{pre} = 84.958; M_{post} = 82.917$). However, the differences between both groups are minimal when expressed in terms of standard deviations, $ES = .30$.

**The TE Awareness Instrument Test**

**Science and Technology by Group**

Compared on science and technology, the two groups of teachers were not significantly different, $F(1, 38) = .489, p = .488$. This finding is consistent for both pre and post tests, $F(1, 38) = 1.166, p = .287$. Yet on average, the two groups showed a
significant increase on science and technology before and after participating in the PD, $F(1, 38) = 102.996, p < .001$.

Table 7

*Descriptive Analysis for the Science and Technology*

<table>
<thead>
<tr>
<th>Group</th>
<th>Time</th>
<th>$M$</th>
<th>$SD$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre</td>
<td>6.750</td>
<td>1.125</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>8.500</td>
<td>.894</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Pre</td>
<td>6.708</td>
<td>1.233</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>8.875</td>
<td>.338</td>
<td>24</td>
</tr>
</tbody>
</table>

*Figure 5.* Science and technology by group.
Figure 5 showed that, over time, group 1 members \( (M_{pre} = 6.750; M_{post} = 8.500) \) and
group 2 members \( (M_{pre} = 6.708; M_{post} = 8.875) \) performed well in the science and
technology scale.

*Technology by Group*

Compared on technology, both groups of teachers were significantly different, \( F (1, 38) = 11.013, p = .002 \). This finding is not consistent for both pre and post tests, \( F (1, 38) = 1.999, p = .166 \). On average, both groups of teachers did not improve on the
technology before and after participating in the PD, \( F (1, 38) = .837, p = .366 \).

Table 8

*Descriptive Analysis for Technology*

<table>
<thead>
<tr>
<th>Group</th>
<th>Time</th>
<th>( M )</th>
<th>( SD )</th>
<th>( N )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre</td>
<td>6.063</td>
<td>1.237</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>5.938</td>
<td>1.692</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Pre</td>
<td>6.625</td>
<td>1.056</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>7.208</td>
<td>.658</td>
<td>24</td>
</tr>
</tbody>
</table>
Figure 6. Technology by group.

Figure 6 showed that, over time, for technology scale, group 1 members did not perform well \( (M_{pre} = 6.063; M_{post} = 5.938) \), whereas, group 2 members did perform better \( (M_{pre} = 6.625; M_{post} = 7.208) \). However, the differences are minimal when expressed in terms of standard deviations, \( ES = .66 \).

Technology Education by Group

Compared on technology education, the two groups of teachers were not significantly different, \( F(1, 38) = .0393, p = .534 \). This finding is consistent for both pre and post tests, \( F(1, 38) = .002, p = .166 \). Yet, on average, the two groups showed a
significant increase on technology education before and after participating in the PD, $F(1, 38) = 118.855, p < .001$.

Table 9

*Descriptive Analysis for Technology Education*

<table>
<thead>
<tr>
<th>Group</th>
<th>Time</th>
<th>M</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre</td>
<td>2.625</td>
<td>1.258</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>5.438</td>
<td>1.094</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Pre</td>
<td>2.792</td>
<td>1.318</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>5.583</td>
<td>.717</td>
<td>24</td>
</tr>
</tbody>
</table>
Figure 7 showed that, for technology education scale and over time, both groups’ members perform well. The program impacted teachers of both group in the same way; group 1: ($M_{pre} = 2.625; M_{post} = 5.438$) group 2: ($M_{pre} = 2.792; M_{post} = 5.583$).

**Overall TE Awareness by Group**

Compared on technology education awareness (combining the three scales), both groups of teachers were significantly different, $F(1, 38) = 4.213, p = .047$. However, this finding was not consistent for both pre and post tests, $F(1, 38) = .773, p = .385$. Yet, on average, the two groups showed a significant increase on technology education awareness before and after participating in the PD, $F(1, 38) = 188.754, p < .001$. 
Table 10

*Descriptive Analysis for Technology Education Awareness*

<table>
<thead>
<tr>
<th>Group</th>
<th>Time</th>
<th>M</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre</td>
<td>15.437</td>
<td>1.861</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>20.313</td>
<td>1.852</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Pre</td>
<td>16.125</td>
<td>2.542</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>21.667</td>
<td>1.204</td>
<td>24</td>
</tr>
</tbody>
</table>

*Figure 8. Technology education awareness by group.*
Figure 8 showed that, for TE Awareness instrument and over time, both groups’ members perform well. The program impacted teachers of both group in the same way; group 1: \(M_{pre} = 15.437; M_{post} = 20.313\) group 2: \(M_{pre} = 16.125; M_{post} = 21.667\).

Overall, group variability between groups 1 and 2 was found to have minimal effect. Therefore, the researcher decided to merge both groups for the remaining of the analyses.

Data Analysis and Results

In the following sections, the researcher presents data analysis and results of the five research questions. The two first research questions were quantitative in nature. However, qualitative findings were added to support both questions’ quantitative results. The three last questions were qualitative in nature. In his approach to the qualitative data analysis, the researcher searched through data from class observations, teachers’ interviews, feedback of the small working group members after class observations, pictures of students’ artifacts and written responses (teachers’ journals and after-session evaluations). Taking into account the research questions, he then coded, categorized and assembled the data. The procedure for reporting the findings includes writing extracts or quotes from participants’ written and verbal responses using confirmatory tactics such as triangulation.

Results of the First Research Question

The first research question was: “What are the effects of technology education professional development (TEPD) on Benin secondary school science teachers’ efficacy
beliefs? In order to address this question, quantitative and qualitative results are presented.

Quantitative Findings: The TETEBI Test

The TETEBI instrument measured participants’ personal TE teaching efficacy belief (PTETEB) and TE teaching outcome expectancy (TETOE). The researcher’s hypothesis was that there was an increase in participants’ TE teaching self-efficacy beliefs after participating in the TEPD program. The data was analyzed first by combining the two subscales (PTETEB and TETOE) and then for the individual scales.

The t-test results indicated that there was no significant change in TETEBI after participating in TEPD $t(39) = .037; p = .97$; between participant pre-TETEBI average score ($M = 83.8; SD = 10.71$) and their post-TETEBI average score ($M = 83.73; SD = 7.21$). Also, no significant difference was found while considering the average scores of the PTETEB and TETOE subscales as shown in Table 11.

Table 11

Paired t-Test Analysis of TETEBI Subscales

<table>
<thead>
<tr>
<th>Paired Subscales</th>
<th>Paired Differences</th>
<th>$t$</th>
<th>$df$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre-PTETEB – post-PTETEB</td>
<td>-.47</td>
<td>-.37</td>
<td>39</td>
<td>.71</td>
</tr>
<tr>
<td>pre-TETOE – post-TETOE</td>
<td>-.34</td>
<td>-.29</td>
<td>40</td>
<td>.78</td>
</tr>
</tbody>
</table>
Qualitative Findings: Teachers’ Beliefs

The theme titled “teachers’ beliefs” is comprised of two components. Teachers articulated clearly the two dimensions of self-efficacy, outcome expectancy and personal teaching efficacy. Outcome expectancy is a teacher’s belief that the educational system can work for all students, regardless of outside influences such as socio-economic status and parental influence, while personal teaching efficacy is a teacher’s belief in his or her skills and abilities to positively impact student achievement.

It is obvious that through their journals and interviews, participants regretted their earlier reluctance to teach TE to students. The reason of this unwillingness was manifestly related to a Benin professional issue that teachers have to be taught something before they try it out. Indeed, teachers wanted to be taught or wanted to have a mastery of the added part of the curriculum before being able to teach it. While blaming their former trainers for not helping them understand what to do, they also acknowledged their lack of enthusiasm to do their job, as indicated in the following extract from a teacher’s journal.

Somebody has to open our eyes concerning the feasibility, the easiness of this teaching…. During other workshops, nobody has approached technology education as we did now. Other trainers were instead theoretical. We never had the chance to make any artifacts nor repair anything at all. Now, we are aware of the wrong we did to our students for not teaching them technology education. Because, in fact, with regard to what we learned during this present workshop, everything required in the curriculum was feasible. (Teacher’s journal, 3/27/08)

Quelqu’un doit nous ouvrir les yeux quant à la faisabilité, le caractère facile de cet enseignement... Au cours des autres ateliers, aucun formateur n’a abordé l’éducation technologique de la manière dont on vient de le faire. Les autres formations étaient plutôt théoriques. On n’a eu jamais à fabriquer des objets technologiques ni réparer quoi que ce soit. Maintenant, nous sommes conscients du tort causé à nos apprenants en ne leur enseignant pas l’éducation...
Demonstration or willingness to teach TE, and to be able to impact students’ learning is correlated to teachers’ self-efficacy. First, participants indicated that the knowledge they gained through the program positively affected their confidence, self-efficacy and readiness in following the technological process to teach TE in their class. Like the majority of participants, one teacher stated:

Before this training, it was practically difficult, even impossible, to teach a technology education class. One doesn’t even know from where to start. I learned a lot during this workshop. So, as a result of the acquired ideas, I can state that I am able to teach technology education and to assist students while making artifacts included in our curriculum. The good part is that, I am competent to assess their works. Truly, this training provided us with the eagerness to teach technology education (Teacher’s journal, 4/4/08)

Avant cette formation, il m’était difficile, voire impossible de délivrer un cours sur l’éducation technologique. On ne savait même pas par où commencer. J’ai beaucoup appris au cours de cet atelier. Ainsi, grâce aux notions acquises, je peux affirmer que je suis en mesure de diriger un cours sur l’éducation technologique, et assister les apprenants dans la fabrication des objets au programme. Ce qui est encore bien est que, je peux évaluer leurs productions. Vraiment, cet atelier a fait de nous des enseignants prêts pour l’enseignement de l’éducation technologique.

Second, participating teachers also claimed that they learned enough through different activities so as to impact their students’ learning. Almost all participants mentioned in their narratives their potential to use the technological process to help student make the artifacts. As one teacher wrote specifically:

Students must understand and master the six steps of the technological process of making objects and repair some objects as indicated in the curriculum. After the identification of the problem, they have to come up with at least two possible solutions for solving the problem, propose the best solution, and explain the
reason of their choice. Everyday recyclable materials should be used to make the object and to refine it if possible. Communication of the final product is also important. In the mean time, criteria will be defined in conjunction with students to assess the final product. (Teacher’s journal, 3/27/08)

Les élèves doivent comprendre et maîtriser les six étapes de la démarche technologique pour fabriquer leurs objets et réparer certains objets comme l’exige le programme. L’étape de l’identification du problème passée, ils devront être capables de proposer au moins deux solutions possibles et choisir la meilleure solution en expliquant la raison de leur choix. Le matériel récupéré dans leur milieu doit servir à fabriquer l’objet et à le raffiner si possible. L’étape de la communication du produit fini est aussi importante. Entre-temps, nous définirons ensemble, les critères pour l’évaluation dudit produit.

Overall, teachers demonstrated the two dimensions of self-efficacy. First, their approval, based on what they learned during the TEPD program, that the portion of their curriculum dealing with TE was teachable, and second, through their resolution and determination, they demonstrated that they were able to teach their students and to impact their learning.

Students interviewed after class observations acknowledged that, for the first time, they were learning while designing and making artifacts. They talked about what they learned through the technological process. Here is the comment from one of students.

We learned a lot in technology education class. The first two steps of the technological process, precisely, the problem identification and solutions proposition steps, are very interesting, because one has to think a lot, and it helps us also to discuss with other friends and to know their ideas. (Student’s open-ended interview)

On a appris beaucoup en faisant la technologie. Les deux premières étapes de la démarche technologique, celles de l’identification du problème et de la proposition des solutions sont vraiment interessantes, car on réfléchit beaucoup
and cela nous permet aussi de discuter avec les autres camarades et de connaître leurs idées.

Results of the Second Research Question

The second research question was “Do Benin secondary school science teachers acquire content knowledge through the TEPD program?” In order to address this question, quantitative and qualitative results are presented.

Quantitative Findings: The TE Awareness Instrument Test

The TE Awareness instrument measured teachers’ TE content knowledge. The three dimensions measured through the administration of this instrument were (1) science and technology (Sci&Tech), (2) technology (Tech), and (3) technology education (TE). The researcher’s hypothesis was that by participating in the TEPD program, teachers’ TE content knowledge would be enhanced. In other words, teachers will acquire the needed technology/pre-engineering skills enabling them to teach TE in their classroom. A dependent paired-samples t test was conducted. Descriptive analysis statistics indicated that difference between the mean score of total posttest ($M = 21.13, SD = 1.62$) and the total pretest ($M = 15.85, SD = 2.29$), was statistically significant. $t(39) = 14.24, p < .001$

Table 12 presents the results of the dependent paired-sample t test considering the total of section-by-section analysis for pretest and posttest.
Table 12

*Dependent Paired-Samples t-Test*

<table>
<thead>
<tr>
<th>Source</th>
<th>Paired Differences</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>PreSci&amp;Tech – PostSci&amp;Tech</td>
<td>-2.00</td>
<td>39</td>
<td>10.55***</td>
</tr>
<tr>
<td>PreTech - PostTech</td>
<td>-0.30</td>
<td>39</td>
<td>1.20</td>
</tr>
<tr>
<td>PreTE - PostTE</td>
<td>-2.80</td>
<td>39</td>
<td>11.26***</td>
</tr>
</tbody>
</table>

*** p < .0001

The findings suggest teachers who attended the TEPD program improved in their science and technology (Sci & Tech) and their technology education (TE). No significant improvement was found in the technology (Tech) knowledge. Overall, combining the three scales, results showed that teachers performed better on the posttest than on the pretest. In other terms, teachers did acquire TE content knowledge subsequent to their participation in the TEPD program.

*Qualitative Findings: Technology Education Content Knowledge*

In science, according to the National Science Teachers Association (NSTA, 2003) standards for science teacher education content includes the knowledge and skills that are learned, or should be learned in the course of the teacher’s professional preparation. Similarly, participating teachers understood that content in TE includes knowledge and skills they have to learn in the course of the TEPD program to be able to teach their
students. As above-mentioned, teacher-participants specified that the activities of the training program were built around the content of the *New Study Programs*.

The TEPD program encompasses two different parts: the theoretical part and the practical part. The theoretical part deals with the general cultural notions in TE teachers should know about before being capable of teaching the subject matter, and the practical part takes into account the multiple technological artifacts to be designed. One teacher provided an account of the theoretical part of the program.

The four days of this professional development opened up new horizons to us, concerning the basic notions of technology education. Indeed, every morning, before starting to make the artifacts, there was a lecture followed by debates. The different lectures included science and technology: relationship and differences, why teach technology education in schools, the notions of the process of design and making technological artifacts, and finally our discussion about the rubrics for assessing students’ work. (Teacher’s journal, 07/04/08)

*Les quatre journées de ce développement professionnel nous ont ouvert des horizons en ce qui concerne les notions de base de l’éducation technologique. En effet, chaque matin avant qu’on ne commence les fabrications des objets, nous avons droit à une conférence suivi de débats. Les différentes conférences ont trait à la relation entre la science et la technologie et leurs différences, pourquoi on doit enseigner l’éducation technologique dans nos écoles, les notions sur la démarche technologique et enfin notre discussion sur la façon d’évaluer les objets faits.*

In addition to the theoretical part of the sessions, teachers stressed the practical part. They all mentioned what they learned and how they learned it. Some of them noted how the making of artifacts was so easy for them, whereas, others indicated how the construction of some objects was difficult. The latter listed the difficulties they were having. Following are the extracts of teachers’ interviews referring to their feelings while making the artifacts.
During the activities, we have fun because, contrary to what we thought, it was so easy to make the objects. We made an electrolysis apparatus, an electrical current detector, a drum, a guitar, and a liquid thermometer. I did not have any difficulties working because the material was available and we were helping each other.

(Group one teacher’s interview)

Au cours de ces activités, on s’est beaucoup amusé car ce qu’on croyait difficile à faire était pourtant facile à réaliser. On a fabriqué un électrolyseur, un détecteur du courant électrique, un tam-tam, une guitare, et un thermomètre à liquide. Pour ma part, je n’ai pas eu de difficulté car le matériel était disponible et on s’entraînait.

I was not used to manipulating tools like the soldering iron. I had some difficulties at the beginning, but I am glad that I made those objects listed in our curriculum. We did not make the liquid thermometer because it was not evident to make. (Group two teacher’s interview)

Je n’étais pas habitué à manipuler des outils tels que le fer à souder. J’ai eu quelques difficultés, mais j’étais content d’avoir fabriqué ces objets qui sont indiqués dans le programme à enseigner. On n’a pas pu fabriquer le thermomètre à liquide parce que ce n’était pas évident.

Results of the Third Research Question

The third research question was: “Do Benin secondary school science teachers acquire pedagogical content knowledge through the TEPD program?” This question was qualitative in nature. However, during data analysis, the researcher performed some frequency counts of characteristics scored by the researcher and his small working group. The research hypothesis was that after participating in the program, teachers would acquire the needed technology/pre-engineering skills to be able to teach TE lessons in their classrooms.

Mishra and Koehler (2006) argued that quality TE teaching “requires developing a nuanced understanding of the complex relationships among technology, content, and
pedagogy, and using this understanding to develop appropriate, context-specific strategies and representations” (p. 1029). That is why TE pedagogical content knowledge is informed by classroom observations and feedback from class observations performed by small group team and the researcher.

After analysis of the data collected from all four classroom observations, the researcher combined the twenty-six questions of the class observation instrument into ten pertinent characteristics related to the implementation of the lesson in the classroom. Table 13 presents the ten characteristics of the TE lesson implementation and the percentage of observers scoring the observation of these characteristics based on the grading codes provided, which were: (1) very well or yes; (2) well or sufficiently well; (3) well enough or sufficiently, (4) unacceptable or insufficient; and (5) null or no. The computation of the percentage is based on the total number of class observations and the number of observers. Each of the four observers (the researcher and the three members of the small working group) implemented four observations and provided in total 16 observation sheets. Then, when 15 sheets out of 16 reported “very well” for the characteristic No 1, the percentage is 93.8. It is important to note that there are no percentages for the grading codes “4” and “5”, at least for the characteristic No 1, because the observations were implemented in the capital city where classroom environment is fairly acceptable.
Table 13

*Characteristics of the Lessons and Percentage of Observers Scoring*

<table>
<thead>
<tr>
<th>No</th>
<th>Characteristic</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>State of the class</td>
<td>93.8</td>
<td>6.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Motivation of students</td>
<td>81.2</td>
<td>12.5</td>
<td>6.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Statement and clarification of the situation-problem</td>
<td>75</td>
<td>18.8</td>
<td>6.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Students’ reformulation of the situation-problem</td>
<td>93.8</td>
<td>6.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Mastery of technology education-related content knowledge</td>
<td>87.5</td>
<td>6.2</td>
<td>6.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mastery of the technological process</td>
<td>87.5</td>
<td>6.2</td>
<td>6.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Encouragement of students’ active participation</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Equipment availability</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Use of the equipment</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Mastery of evaluation process</td>
<td>75</td>
<td>18.8</td>
<td>6.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The characteristic No 1, state of the class, deals with the overall evaluation of the physical classroom environment, including seating arrangement, furniture in the class, ventilation of the class, displacement space in the class, etc. Characteristics 2, 3, 5, 6, 7, and 10 are related to the teacher’s activities and skills and teaching strategies in the classroom. For example, motivation of students, which is characteristic No 2, pertains to the extent to which the teacher introduced the lesson, mobilized students’ attention and interests. These characteristics are important during class observations. In order to receive a good score, teachers should be able to motivate their students, guide them
through the technological process (identify and formulate clearly the problem, elaborate at least two solutions, choose the best of the solutions and explain this choice, design and make the chosen artifact, assess the process and test the product, and communicate the result to others) learned during the PD program, and assess students’ artifacts. Characteristics 8 and 9 are related to equipment used by students to design their artifacts. Finally, characteristic No 4 is connected to students’ voice in the classroom, as well as the technological process the latter are supposed to learn.

The researcher and the small group members highly scored the observed teachers in the area of TE pedagogical content knowledge. In addition, observers’ comments indicated that teachers practiced what they learned during the TEPD sessions. There was a consensus among observers that teachers, in all four classes, were teaching a topic learned from the TEPD program and contained in the New Study Programs. Using the technological process learned during the training, teachers were assisting students while they designed and made their artifacts in small groups. A member of the small group feedback, after classroom observation, made the following observation.

The teacher has a solid grasp of the subject matter content inherent to the object to be made. He fully led students through the steps which are: (1) identification and definition of the problem; (2) elaboration of many potential solutions; (3) choice of the best solution; (4) designing of a plan and elaboration of a prototype; (5) assessment of the process and test of the product; and (6) refinement of the product and communication of the result. Acknowledging that the process shouldn’t have to be always linear, the observed teacher did a great job.

(Feedback from a member of the small group)

*L’enseignant a une solide maîtrise du contenu de sa matière relatif à l’object à fabriquer. Il a complètement conduit les apprenants à travers les étapes de la démarche technologique qui sont: (1) identifier et définir le problème; (2)
elaborer plusieurs solutions possibles; (3) choisir la meilleure solution; (4) mettre en oeuvre un plan et élaborer le prototype; (5) évaluer le processus, tester le produit; et (6) raffiner le produit, et communiquer le résultat. Reconnaissant que la démarche technologique ne devrait pas être toujours linéaire, nous pouvons dire que l’enseignant a été parfait.

Feedback from observers also pointed out the climate of respect in which students were working, how the visited teachers were acting as resource persons for students, and how they provided students with useful advice when the latter had problems. Also, students corroborated the changes in their teachers’ behavior with regard to TE teaching. In other words, they demonstrated their willingness to see their teachers change and to keep working on making technological objects. Here is the summary of two eighth grade student responses, when asked to express their feelings after a TE class.

I am so glad to make these technological artifacts. Because, since I started sixth grade, that is the first time we are dealing with the technology education portion of the program. Usually, teachers avoid making artifacts with us. We don’t know why. (Students’ open-ended interview)

Je suis très content de fabriquer des objets technologiques. Car depuis que j’ai commencé la 6e, c’est la première fois qu’on aborde la partie sur l’éducation technologique. D’habitude, les professeurs évitent d’aborder avec nous la fabrication des objets. Nous ne savons pas pourquoi.

We have a lot of fun while making the drum. For the first time we are learning technology education, we have not seen time goes by. It would be nice to keep doing this and make all artifacts included in our program. (Students’ open-ended interview)

On s’est beaucoup amusé lors de la fabrication du tam-tam. Pour la première fois qu’on fait l’éducation technologique, on n’a pas vu le temps passé. Ce serait bon si on pouvait continuer comme cela et fabriquer tous les objets incrits au programme.
Results of the Fourth Research Question

The fourth research question of this study was: “To what extent do Benin secondary school science teachers teach the technology education lessons in their classroom following the TEPD program?” In addition to class observations showing that teachers were teaching the TE lessons, anecdotal reports from small working group members and other pedagogical advisors indicated that participating teachers were effectively teaching the TE lessons learned in their classrooms. One of them reported:

Some of the teachers who participated in the TEPD program are from my school district. During our last school district’s meeting, they acknowledged the significance of the PD program, and decided to collect the materials needed to make certain artifacts, in order to teach the TE lessons in their class. (Small group member’s anecdotal report)

Certains des enseignants ayant participé au programme sont de ma zone. Au cours de notre dernière rencontre, ils ont reconnu l’importance de cet atelier et on décidé de collecter le matériel dont ils auraient besoin pour fabriquer les objets, de façon à enseigner l’éducation technologique dans leurs classes.

While some teachers were planning to teach the lessons learned, others were effectively teaching these lessons in their class. Another small group member reported:

Last week, in my school district, I observed two teachers, both were participants in the TEPD program. I noticed that they were teaching TE lessons. One was making with his students the drum, whereas, the second was teaching how to make the guitar. During our school district’s meeting, we decided to teach other teachers the technological process to make the artifacts. (Small group member’s anecdotal report)

La semaine dernière, dans ma zone, j’ai rendu visite à deux enseignants, qui étaient tous deux des participants à l’atelier. J’ai remarqué qu’ils enseignaient des cours d’éducation technologique. L’un d’eux enseignait le tam-tam, alors que le second enseignait la guitare. Au cours de la réunion des enseignants de ma zone, nous avons décidé d’enseigner aux autres enseignants la démarche technologique pour fabriquer les objets.
Qualitative data analysis indicated that participating teachers acknowledged the significance of teaching TE to their students, and decided to teach the TE portion of the mandatory curriculum and to pass on the knowledge acquire during the TEPD sessions and to encourage other teachers to teach it. They also demonstrated how much they valued TE and the curriculum.

Participating teachers saw the competency-based new curriculum that introduced TE as a component of the physical science curriculum as an asset for secondary school students. Underlying themes in their comments were the value-added of TE for students’ knowledge and problem solving skills in the short term, and in the long term, the benefit of the knowledge acquired for students’ lives, the community and the country. Overall, they stressed (1) the advantages of teaching TE to students, (2) the impact of that teaching in the development of the country, and (3) teachers’ responsibility while teaching it.

Different comments were put forward to underline the advantages of teaching TE to students. For some teachers, teaching TE to students is important because that could develop in them transversal and disciplinary competencies and motivate their creativity. One example that illustrates that issue is the statement below by one of the participating teachers.

According to me, technology education helps the student to master the technological process that stimulates his curiosity, excites his creativity, provides him with inventive ideas and convinces him as he practices that nothing is magic; every observable fact is explicable and can be reproduced. (Teacher’s journal, 2/19/08)
A mon avis, l’éducation technologique permet à l’apprenant de mettre en œuvre la démarche technologique qui aiguise sa curiosité, stimule sa pensée créatrice, son esprit inventif et qui le convainc de jour en jour qu’il n’y a rien de magique, que tout est explicable, donc reproductible.

For other teachers, TE is a subject students need to learn in order to be aware of environmental issues and acquire problem-solving skills. As one teacher indicated:

When students learn technology education, they are receptive to environmental problems. There are given more opportunities to be creative, to think logically, to see and understand a technological problem in total, and to act responsibly as they work to solve problems that are important to them. (Teacher’s journal, 3/28/08)

A travers l’éducation technologique, les apprenants ont conscience des problèmes environnementaux. Ils ont plus d’opportunité d’être créatifs, d’être logique dans leur raisonnement, de voir et de comprendre globalement un problème technologique, et d’agir de façon responsable dans leur démarche de résolution des problèmes qui leur sont importants.

Other participants were calling attention to the competency-based curriculum in use. They referred to the foundations and values underlined in the curriculum. Finally, they acknowledged their responsibility in the process for assisting students to take control of their own learning.

Excellence is the fundamental value of our educational system. Intellectual, cultural and moral values are the basis of the New Study Programs founded on competency-based approach. Concerning the physics, chemistry and technology part of these programs, technology education is of paramount significance. Indeed, its objective is to prepare men and women capable of taking charge and assuming their role in the society. In that matter, the teacher’s role is to help students take ownership of the savoir-faire in order to create at the end of his studies productive activities and to contribute to the nation’s development. (Group One teacher’s interview)

L’excellence est la valeur fondamentale de notre système éducatif. Les valeurs intellectuelles, culturelles et morales sont la base des Nouveaux Programmes d’Etudes basés sur l’approche par compétences. Dans ces programmes pour ce
qui concerne les Science Physique Chimie et Technologique, l’éducation technologique a une place importante. En effet, son objectif est de former des hommes capables de se prendre en charge et d’assumer les grands rôles dans la société. Pour cela, l’enseignant a le devoir d’aider les apprenants à s’approprier des savoir-faire afin de créer à la fin des études des activités productrices, et de contribuer par ce fait au développement de la nation.

Results of the Fifth Research Question

The last research question was: “How do Benin secondary school science teachers perceive their own TEPD experience?” In order to answer this question, a qualitative analysis has been performed. The researcher’s hypothesis for this question was that after participating in the program, teachers would acknowledge its soundness and effectiveness.

Our perceptual differentiation (the ability to perceive, compare, and contrast qualities) increases as people mature, and is influenced by our experience (Eisner, 1972). Through their journals and interviews, participating teachers expressed what they experienced during the TEPD sessions. Their perceptions about what they experienced included their involvement in the activities, the teamwork, their future role as TE teachers, comparison with other PD, and the responsibility of the Ministry of Education in training teachers.

Teachers explained how they were involved in the TEPD activities and how much fun they had while making the artifacts. All participants were surprised that those artifacts could be made with recyclable materials. As one teacher noted:

I participated to the workshop not like an observer, but like an actor… We really liked the practical part of the workshop. We were surprised every time that the “supplies” equipment was given to us, because those equipments were everyday
recyclable materials. And… it was easy to make the objects. (Teacher’s journal, 1/4/08)

J’ai participé à cet atelier non pas en tant qu’observateur, mais en tant qu’acteur… On a vraiment aimé le côté pratique de cet atelier. Chaque fois que les encadreurs nous présentaient les matériels, on était surpris car c’est des matériels récupérés ou recyclés. Et puis, …c’était assez facile de fabriquer ces objets.

Teamwork was an aspect of the training that teachers appreciated. They mentioned during the interviews that working in small groups helped them understand and complete their artifact in a short time. They acknowledged that the directions provided by the researcher and the small group members were of great help in accomplishing their work.

All participants pointed out the potential impact of the TEPD program on their future role as teachers. They specifically praised the constructivist approach of guiding students through the technological process of designing and making the objects. The simplicity of this would allow them to step back and watch their students acquire knowledge.

This workshop is very valuable to us, because the technological process that we learned will facilitate our job in our classroom. Our job will consist of guidance, assistance, and advice. (Teachers interview).

Cet atelier est très bénéfique pour nous, car la démarche technologique que nous avons apprise nous facilitera la tâche lorsque nous serons dans nos classes. Il s’agira de guider les apprenants, de les observer travailler et de les conseiller.

Teachers compared the present training to other workshops that they participated in, which were organized and funded by the government through the Ministry of Education. According to them, the TEPD program was much better and useful than the
former trainings that the Ministry of Education and its various directorates provided in the scope of the expansion of the New Study Programs. Finally, they criticized the non-involvement of the Ministry in the present training. They indicated that it was the Ministry’s responsibility to provide funding for the workshop, because of its important objective for helping teachers understand and teach TE.

Teachers provided feedback about the effectiveness of the TE PD program. Effectiveness of the TE PD program was a recurrent theme in teachers’ journals, post-session evaluations and interviews. Effectiveness of the program was viewed in terms of teachers’ satisfaction during and after participating in the program. For teachers, the program was effective for many reasons, including (1) its content, (2) its organization, (3) the expertise of the team, and (4) the meals provided by the researcher.

Concerning the TE PD program content, participants mentioned that the program was effective because it focused on TE activities that were really needed and realistic. Those activities are contained in the curriculum. One teacher noted in his post-session evaluation:

Truly, this workshop is welcome, because that is the first time, since the expansion of the New Study Programs that I am working with the material to make technological artifacts. In addition, these artifacts are those included in the curriculum that we were supposed to teach to our students in school. (Post-session evaluation, 3/25/08)

Cet atelier est vraiment le bienvenu car c’est la première fois, depuis la généralisation des Nouveaux Programmes d’Étude, que je touche au matériel pour fabriquer des objets technologiques. De plus, ce sont des objets qui sont contenus dans le programme et que nous sommes censés enseigner à nos élèves dans nos établissements.
Teachers praised the whole organization of the program. Through their journals, they spoke highly of periods scheduled for its delivery, the workshop agenda, and the availability of materials for making artifacts. At the end of the first group sessions, one teacher made a comprehensive comment related to how the program went.

I think that the organization of this training was perfect. We did work without time constraint and the working conditions were neat. Indeed, the workshop was organized during spring and Easter breaks. It took into account our pre-established agendas. Activities scheduled for the day were thoroughly accomplished and the working materials for making technological artifacts were available, even though sometimes there was lack of some items. (Teacher’s journal, 3/27/08)

Participants positively appraised the researcher and the small working group members’ expertise during the TEPD sessions. On his post-session evaluation sheet, one teacher depicted the friendly atmosphere that prevailed during the first session.

Sincerely, I was expecting some lectures on how to make technological artifacts, but I was pleasantly surprised the first day, when after the lecture and our discussions, we started making the electrolysis apparatus and the electric current detector. The researcher and his team were acting as monitors or mentors. They provided us with advice and directions. In addition, they were open-minded and were accepting any contribution from participants. Nothing was imposed on us, and we were helping each other to complete the designed artifact. (Teacher post-session evaluation, 3/28/08)

Sincèrement, je m’attendais à des cours théoriques sur la fabrication des objets technologiques, mais j’ai été agréablement surpris le premier jour, lorsqu’après la conférence et débats, on a commencé la fabrication l’électrolyseur et le détecteur du courant électrique. Le chercheur et les encadreurs agissaient comme
des guides. Ils nous ont donné des directives. En plus, ils étaient ouverts à tout apport de la part des participants. Ils ne nous imposaient rien et on s’entraidaient jusqu’à la réalisation complète de l’objet.

The effectiveness of the program was also related to the sustenance provided during the workshop. They talked about the refreshments and the meals supplied by the researcher. Following is the narrative of one teacher-participant.

Even though we did not receive honorariums at the end of the sessions, it is well to note that we have been spoiled in terms of nourishment. At the beginning, the trainer told us he could not pay or give us a stipend, but food will be provided. In fact, he kept his word, because there were coffee breaks and lunch-breaks; and the food was good. One cannot ask more. (Teacher’s journal, 04/04/08)

Même si on n’a pas perçu des perdiems à la fin des activités, il faut avouer qu’on a été gâté côté nourriture. Le formateur avait été clair au début qu’il ne pouvait pas nous récompenser avec de l’argent, mais qu’il allait assurer la restauration. En définitive, il a tenu parole, car il y a eu des pauses cafés et des pauses déjeuners. En plus, la nourriture a été de bonne qualité. On ne pouvait pas mieux demander.

Summary

Results of the five research questions were presented in this chapter. Results to the first question indicated that teachers’ self-efficacy was not enhanced after their participating in the program, whereas, teachers’ TE content knowledge was improved as shown in the second question’s results. Overall, teachers welcome the TEPD program, acknowledged that they learned how to make technological artifacts, demonstrated their willingness to teach the subject to their students, and were following the technological process while teaching it to students. Finally, they decided to pass on their knowledge of TE to other teachers.
For trustworthiness concerns, several precautions have been taken while analyzing qualitative data. Indeed, throughout this analysis, the researcher tried to be non-judgmental about some issues, such as teachers’ beliefs, in accordance with the suggestions of previous researchers (Tiezzi & Cross, 1997). Although it was occasionally difficult to separate the researcher side from the teacher educator side, he felt strongly that it was not his goal to criticize or praise his participants’ beliefs and practices, but rather to describe and analyze.
CHAPTER V
DISCUSSIONS, IMPLICATIONS, AND RECOMMENDATIONS

After careful and thorough analysis of quantitative and qualitative data, the researcher identified five sections which would constitute the core of this chapter. The first section restates the purpose and summarizes the theoretical framework of the study. The second section deals with the effectiveness of the technology education professional development (TEPD) program, including the discussion of the results of each of the five research questions. The third section, reports the relationship between self-efficacy, technology education (TE) content knowledge and TE pedagogical content knowledge. The fourth section expounds implications that are inferred from the results of the study. Finally, the fifth section proposes some areas of further inquiry. Following these five sections, the researcher concludes with his reflection and deliberations with regard to his options for his dissertation research.

Purpose and Theoretical Framework of the Study

Restatement of the Purpose of the Study

Two major purposes, a research purpose and a practical purpose (Maxwell, 1996) were at the core of this study. The research purpose was to explore participating teachers’ self-efficacy beliefs to teach the TE portion of their mandatory curriculum after participating in TEPD program, to investigate their TE content knowledge and pedagogical content knowledge and their perceptions related to their TEPD experiences. The practical purpose of the study was to provide Benin secondary school physical
science teachers with an effective TEPD program which would endow them with
different experiences, including learning TE, teaching it, learning to make technological
artifacts, and learning to design TE assessment rubrics.

Summary of the Theoretical Framework of the Study

The TEPD program designed in this study has two objectives. The first objective
was to be an effective PD and the second dealt with the concept of teacher change. Both
objectives are interrelated because when a PD is effective, it often may change teachers’
behaviors and beliefs. In order to be effective, many concerns, particularly cultural and
contextual issues were addressed during the implementation of the PD. Also, the theory
of teacher change was used to design the study. Five perspectives on teacher change were
described, including change as training, change as adaptation, change as personal
development, change as local reform, and change as growth or learning. It should be
noted that change as training, adaptation, local reform, and growth are connected to this
study and “these alternative perspectives on teacher change are not mutually exclusive,
and that many are in fact interrelated” (Clarke & Hollingsworth, 2002).

Effectiveness of the TEPD Program

It was the researcher’s intention to provide teachers with an effective TEPD
program. After analysis of the data gathered, the researcher found many characteristics of
this program, including (a) enhancement of teachers’ content and pedagogic content
knowledge, (b) promotion of collegiality and collaboration exchange, (c) alignment with
curriculum reform initiatives and teachers’ needs, (d) consideration of cultural and
contextual issues, (e) careful thought to trainers’ expertise, and (f) teachers’ beliefs and
teacher change. Prior studies, particularly Guskey’s (2004) review of literature, found these traits as important for an effective PD. The researcher explicitly addressed and discussed research questions No 1 through 4, whereas response to question No 5 was implicitly in the text. Indeed, the researcher utilized participating teachers’ perceptions of their own TEPD experience to corroborate certain assertions.

Enhancement of Teachers Content and Pedagogical Knowledge

Content and pedagogical content knowledge were taken into account during the delivery of the program. Indeed, analyses of research questions No 2 and 3 demonstrated that teachers’ TE content and pedagogical content knowledge were enhanced due to their participation to the PD program.

Technology Education Content Knowledge

Teachers’ mastery of the content of the program was explored using the TE Awareness instrument encompassing three scales: science and technology, technology, and technology education. Descriptive statistics indicated that teachers’ content knowledge increased in the areas of science and technology (Table 7, Figure 5) and technology education (Table 9, Figure 7). In the area of technology, participating teachers did not perform well (Table 8, Figure 6). However, considering teachers’ membership and looking at practical significance, rather than statistical significance, the effect size (ES) computed for members of group 2 indicated a large difference effect, $ES = .66$, meaning these teachers’ knowledge in technology increased over time. Overall, after merging both groups of teachers, results of the TE Awareness instrument indicated that statistically significant improvement was observed in teachers’ TE content knowledge,
$M_{pre} = 15.85, SD = 2.29; M_{post} = 21.13, SD = 1.62$) after participating in the PD program, $t(39) = 14.24, p < .001, (ES = 2.55)$.

These quantitative results were corroborated by qualitative data analyses. Indeed, analysis of documents indicated enhancement in teachers’ TE content knowledge due to their participation in the program. In their reports, teacher-participants mentioned that the program combined theory and practice, and that they have had the opportunity to listen to lectures delivered by the researcher on science and technology education issues, debate and ask questions about those topics, design and make technological objects in small groups, design rubrics to assess their own artifacts, and reflect about their learning and practices. Jones and Compton (1998) supported this when they noted that one crucial way to develop the content knowledge in technology is to reflect on technological practice. On the other hand, many studies found that knowledge of the content is the cornerstone of the success of a PD. “Continuous improvement in knowledge, skills, and understandings is key to teacher learning” (Loucks-Horsley et al., 2003, p. 218).

Having teachers write journals and reflect about their learning and practice after each session of the program was a major asset of the TEPD program. It was also an innovation in the history of PD programs implemented in Benin. The researcher believes that, as an important part of their trainings, teachers should learn to ponder their learning and practice and write journals.

Technology Education Pedagogical Content Knowledge

Frequency counts of topics included in the class observation instrument revealed that the researcher and the small group members highly scored the observed teachers
(Table 13), meaning that the latter became proficient at teaching TE in their classroom. Indeed, the consensus among observers laid out in their grading and feedback signified that teachers knew effective strategies for teaching the technological process to students and guided the latter in making their objects. Also, interviewed students confirmed this assertion and explained how they learned, and the help that they received from their teachers while making the artifacts.

In short, the program was effective through the improvement of what Shulman (1987) has termed “pedagogical content knowledge,” as it emphasized the subject matter teachers were expected to teach and the teaching methods teachers were expected to employ. Indeed, the program provided teachers with opportunities to develop knowledge related to TE and broaden their teaching approaches, so they can create better opportunities for students. In that sense, the TEPD program engaged teachers in learning experiences that enhanced their understanding of major TE concepts and pedagogy. It also enabled teachers to make decisions about implementing the curriculum in their classroom. Bybee and Loucks-Horsley (2000) found this trait of an effective PD as they said:

… teachers need to learn about and develop skills related to technology; they need opportunities to deepen their content knowledge. … teachers need opportunities to learn about how to teach technology – to combine their content knowledge with what they know about learning and how to teach their particular content. (p. 31)

One of the strengths of this research was the completion of class observations after implementation of the TEPD program. Even though many scholars acknowledged
that outcomes of a PD are not observable in the short term, the researcher maintained that the follow-up of a PD in school settings was a major aspect and necessary in the context of this new curriculum in use in Benin, to make sure that teachers are applying what they learned during the PD program. For the researcher, class observations were important after the program to investigate how teachers have changed in their classrooms practices.

Promotion of Collegiality and Collaboration Exchange

Promotion of collegiality and collaboration exchange is a consistent noted characteristic of an effective PD. Loucks-Horsley et al. (2003) stated that “effective professional development provides opportunities for teachers to work with colleagues and other experts in learning communities to improve their practice” (p. 47). The TEPD program was effective because session activities promoted collaboration among participants. Bandura’s (1986) physiological and emotional states’ source of efficacy expectations was addressed through this collaboration. Participants were working in small groups of three or four, exchanging ideas, sharing strategies and expertise, and challenging ways of making artifacts. In addition, the atmosphere was enjoyable and relaxed, allowing teachers to network.

The researcher found that helping teachers collaborate and network is important to improve their teaching or practice. In Benin, teachers are often working in isolation, without communicating with their colleagues, because they are involved in other businesses. Working in collaboration and networking were two other benefits of the TEPD program to enable teachers to learn from one another, share ideas about TE, and expectantly keep in touch in the future.
Alignment with Curriculum Reform Initiatives and Teachers’ Needs

Aligning and implementing curriculum, one of the six categories for professional learning identified by Loucks-Horsley et al. (2003), was included in the present TEPD program. Curriculum strategies involve teachers with the actual learning experiences and materials they will use with their students (Loucks-Horsley, 1999). The PD program was coherent with the content and the pedagogy teachers should know to be able to teach the curriculum. Participants’ perceptions toward the content of the PD activities were generally more positive, as the latter focused on providing teachers with new knowledge in TE and developing their skills in teaching the technological process of designing and making artifacts. They clearly felt that the program in which they were involved had met their needs. Bybee (2001) found that “the characteristics of effective professional development for technology educators are active learning, focusing on concepts and processes from technology standards, learning within the context of the curriculum they have to teach, and collaborative learning” (p. 2). In sum, the researcher found that the program was effective because, during the sessions, teachers did learn how to implement the New Study Programs materials with regard to TE.

Like many other scholars, the researcher believes that an effective PD should focus on teachers’ needs. Zannou (2004) mentioned that prior PD programs, implemented during the expansion of the new curriculum in Benin, did not take into account what teachers should learn to be able to teach TE lessons. Therefore, the researcher explored teachers’ needs and utilized that new curriculum as a working document to design the content of the TEPD program.
Consideration of Cultural and Contextual Issues

Like many other developing countries, Benin’s educational system encounters different issues, including pre-service teacher preparation, in-service teacher training, teacher workload, teaching conditions, lack of full-time contracts, lack of teaching materials, lack of supervisory activities, etc. The list of those cultural and contextual issues that hinder the teaching practices in Benin is not exhaustive.

The Superior Normal School in the capital city is the only public training institution in charge of a limited number of secondary pre-service teachers. Even though other private training centers have been created in the country, the problem of pre-service teacher preparation is still crucial. In-service teachers’ trainings are quasi non-existent. Although pedagogic advisors have been appointed to perform school site and district-wide PD programs, there are still concerns related to the effective implementation of these trainings.

In Benin, teachers are overwhelmed with their workload and their dreadful teaching conditions. Secondary school teachers face congested teaching hours because of the shortage of teachers, overloaded curriculum, overcrowded classroom, and are generally “the most poorly paid of all professional workers” (Fafunwa, 1967). Most of them do not have a full-time contract with public schools. Indeed, because of the lack of financial resources, the government is unable to recruit and sign full-time contracts with many teachers. Consequences resulting from this situation are multiple. First, to make ends meet and to ameliorate their living conditions, teachers are compelled to get involved, despite their busy schedules, in other businesses, such as teaching in private
schools and tutoring. Second, in addition to their workload, teachers do not feel like participating in PD programs designed for them. As a matter of fact, they are conscious that participation in a PD session in Benin does not provide them with Ministry certification, university credentials, career enhancement, or salary enhancement. Finally, school administrators and pedagogical advisors fail to design and carry out efficient supervisory activities. The latter activities are almost non-existent, because supervisors are also overloaded and poorly paid.

Many scholars working in developing countries stressed the persistent lack of didactic textbooks, science teaching materials, and lab equipment. To denounce the difficult condition in which teachers work in Africa, Fafunwa (1967) utilized the following metaphor.

The African teacher of today is like a farmer who cultivates his farm sometimes with bare hands, sometimes with an antiquated hoe or any other crude instrument that is available. He sometimes succeeds, but often fails, not because he enjoys the opium of failure, but because he can only practice what he knows and use the material available to him. (p. 82)

Finally, it is noticeable that teachers will not try out the topics they did not learn during their teacher preparation. This could be traced to the colonial-type of education received by some African scholars or teachers. Teachers are not empowered to learn by themselves, take ownership and be creative. A manifest proof of this situation is that teachers neglected the portion of the TE curriculum, because they were not trained.
The TEPD program designed was effective as it took into consideration most of these issues. First, the program dealt with the subject they needed to learn to be able to teach their students, meaning the program was aligned with the content of the curriculum. Second, participating teachers mentioned when they were contacted that they could not attend the sessions during weekends; so the researcher made arrangement to meet their requirements. The program was implemented only during breaks and holidays. Teachers highly appreciated the whole organization and the agenda of the program. Third, when the researcher was unable to provide incentives, such as honorariums, certification or official recognition, or salary advancement, that are critical for the success of a PD, and then constitute a characteristic of an effective PD, he provided teachers with refreshments and meals. Teachers were delighted with the thoughtfulness they received with regard to the sustenance. Indeed, the researcher was aware that, procurement of meals and refreshments is important when working with teachers. In African tradition, especially in Benin tradition, sharing food with workers or guesses constitutes a way of building trust. Finally, it was the researcher’s intention to equip participant-teachers with necessary materials to allow them to make the artifacts before going before students. Unfortunately, the lack of funding did not permit this equipment. However, the researcher did bestow some teachers some basics materials used during the PD.

With regard to his findings, the researcher insists on the fact that a PD program implemented in developing countries, especially in African countries, should take into consideration cultural and contextual issues. Those concerns are ingrained in people’s way of living. So, ignoring them is to jeopardize the success of the program.
Careful Thought to Trainers’ Expertise

Expertise of the trainers is an important trait of effective PD; even though it was not mentioned within lists of characteristics of an effective PD. Trainers should be knowledgeable about activities to be taught before working with teachers. During the expansion of the *New Study Programs* in Benin, secondary school science teachers stated that they did not gain any knowledge from the PD because their trainers were not familiar with the topics they were talking about (Zannou, 2004). That is why, before even meeting with teachers, the researcher received an informal training at the College of Technology at Kent State University. He also designated as members of the small working group, an erudite teacher from one of our vocational and professional training centers and institutes, and two high school science teachers who are well-informed in TE topics. Therefore, careful consideration to teachers’ trainers was critical for the effectiveness of the TEPD program.

Even though there is a lack of consensus with reference to characteristics of effective PD program, this study indicated that expertise of trainers is an important trait to be added to the list. This feature is obvious for developing countries where most of the time, trainers imported from developed countries, are unaware of people’s contextual realities. In that sense, another strength of this program was its delivery by local experts who were knowledgeable in TE subject matter and how to make technological artifacts.

Teachers’ Beliefs and Teacher Change

In this section, the researcher dealt with research questions No 1 and 4. Question 1 investigated the effect of the TEPD program on participating teachers, whereas,
question 4 explored the extent to which teachers’ teach TE after participating in the program.

The primary work of effective PD is to change teachers’ beliefs and attitudes. Loucks-Horsley et al. (2003) indicated, “All educational changes of value require individuals to act in new ways (demonstrated by new skills, behaviors or activities) and to think in new ways (beliefs, understandings, or ideas)” (p. 48). The effectiveness of the TEPD program was evaluated in terms of how teachers’ attitudes and beliefs changed in relation to their ability to effectively teach TE topics to their students. Descriptive results of the technology education teacher efficacy beliefs instrument (TETEBI) indicated that there was no significant difference in teachers’ self-efficacy beliefs, $t(39) = .037, p = .97$. That is to say, participation in the TEPD program did not affect teachers’ self-efficacy in teaching TE. However, due to the small size of sample and the complexities of the analysis resulting in a low power analysis, as well as a low reliability, the researcher thought that it would be more reasonable to look at the practical significance rather than statistical significance. When considering teachers’ membership and the two scales of the TETEBI, the researcher noticed that for group 1 teachers’ outcome expectancy scale (Table 4, Figure 2), the effect size (ES) computed, $ES = .43$, indicated a moderate effect. Also, for group 1 teachers’ personal teaching efficacy scale (Table 5, Figure 3), the effect size computed, $ES = .36$, showed a moderate effect. Therefore, teachers of group 1 were moderately impacted by the program. These quantitative results were substantiated by the qualitative data analysis; the latter strongly indicated that both personal TE teaching
efficacy beliefs (PTETEB) and TE teaching outcome expectancy (TETOE) were enhanced as a result of teachers’ participation in the PD program.

In chapter 4, the qualitative theme, titled “teachers’ beliefs”, expounded how the program positively impacted teacher-participants. The latter appreciated the whole organization and the activities completed during the program. After participating in the program, teachers expressed their regret for neglecting the TE portion because it was teachable, and they demonstrated their willingness to teach it and to be able to impact their students’ learning. Personal TE teaching efficacy was enhanced, because teachers expressed that they mastered the technological process of designing and making artifacts, which is the basis of teaching TE and that they were confident and ready to teach.

Teachers’ TE, teaching outcome expectancy also increased, since participants claimed in their narratives and interviews their potential to use the knowledge that they received to walk students through technological process and to help them make the artifacts included in the curriculum. Indeed, Khourey-Bowers and Simonis (2004) noted:

Professional development results that indicated enhanced self-efficacy among teacher-participants would expect evidence of teachers’ perceptions that their students are able to learn, a greater likelihood to utilizing teaching strategies that allow students more variability in their classroom behavior, and a greater recognition of supportive environmental factors. (p. 188)

In addition, students interviewed after classroom observations indicated that they understood the process of designing and making artifacts. They stipulated that it was the first time their teacher was teaching the portion of the curriculum related to TE and that
they learned a lot and enjoyed it. Therefore, positive changes and improvements were made as compared to how teachers were neglecting the TE portion of the new curriculum in use in Benin.

Different types of change noticed in teachers’ views regarding TE and its teaching were addressed in research question No 4. Change as training was observed as participating teachers improved their knowledge of TE concepts and their technological skills, and became aware of the technological process they would use to teach their students. At the end of the training, teachers suggested the replication of the program for a complete change in their attitudes.

Change as adaptation was remarkable. Teachers decided, in response to their participation to the training and the knowledge gained, to teach the neglected portion of the curriculum. Class observations showed that teachers were assisting students to make artifacts utilizing the technological process learned during the program.

Change as personal development was noticeable during the sessions. Aware that TE lessons and activities were teachable, teachers sought to change and learned as much as possible during the training. Their sudden enthusiasm to perform the activities demonstrated that they wanted to learn technological skills and the technological process and to improve their performance in class.

Change as local reform was decided at teachers’ levels, as they decided to teach effectively the portion they neglected in the curriculum. They also suggested the replication of the present program or to train their peers who did not attend the program
so they can be at the same level of knowledge and to be capable to teach, like they were doing.

Finally, change as growth or learning was the central focus of the present program. Teachers see PD programs as among the most promising and most readily available routes to growth on the job (Fullan & Stiegelbauer, 1991), not only as a way to combat boredom and alienation, but also as a pathway to increased competence and greater professional satisfaction (Huberman, 1995). Throughout their journals and post-session evaluations, it was obvious that participating teachers learned the content and the pedagogy of TE, and demonstrated their willingness to impact students’ learning.

In sum, the TEPD program provided in the scope of this study was effective, as it enhanced teachers’ self-efficacy beliefs. Teachers acquired TE content knowledge and pedagogical content knowledge and started teaching the TE portion of the curriculum to their students. Important changes were observed as training, adaptation, local reform and growth.

**Relationship between Self-Efficacy, Technology Education Content and Pedagogical Content Knowledge**

Wheatley (2005) indicated that teachers’ content knowledge, pedagogical content knowledge, and teaching skill are powerful variables to be taken into account when studying teachers’ efficacy. The concept of self-efficacy is interrelated to the notions of content and pedagogical content knowledge. An enhancement of the two dimensions of self-efficacy cannot be accomplished without a mastery of content and pedagogical
content knowledge. Khourey-Bowers and Simonis (2004) supported this view through their longitudinal study of middle grades chemistry.

Participants’ beliefs significantly improved in relation to their ability to effectively teach science concepts. These changes are often correlated with increased science content knowledge and pedagogical content knowledge. …the professional development program effectively implemented strategies to enhance chemistry conceptual knowledge and pedagogical strategies (learning cycle), which, in turn, positively influenced teachers’ self-efficacy (PSTE). (p. 192)

Therefore, enhancement in participating teachers’ TE content knowledge observed through quantitative and qualitative data analyses and improvement in their TE pedagogical content knowledge, have resulted in the changes in teachers’ both personal TE teaching efficacy beliefs (PTETEB) and TE teaching outcome expectancy (TETOE). This is consistent with Shulman (1987) and said that “teachers need to develop content knowledge as well as pedagogical knowledge” if they want students to achieve.

The remainder of this chapter deals with the implications of the study, the recommendations for further research and some comments as conclusion.

Implications of the Study

Results of this study indicated that the TEPD program positively impacted participating teachers. Teachers acknowledged the relevancy, the soundness, and the effectiveness of the program. Various suggestions made in their journals for the replication of the program, and for its expansion to every teacher across the country, demonstrated how the program was transformative for them. Consequently,
interpretations of the results led to ten educational implications that could improve TE teaching in secondary school settings in Benin, as well as in other developing countries with similar features. These implications include: (1) implication for a pressing teacher PD in TE; (2) implication for Benin science teachers’ empowerment; (3) implications for Benin education; (4) implication for Benin’s economic future and sustainability; (5) implication for a transformative TE curriculum evaluation; (6) implication for the procurement of teaching materials; (7) implication for meaningful incentives in teacher PD; (8) implication for designing assessment tools in TE teaching; (9) implication for including TE in teacher education program; and (10) implication for a holistic TE teaching. As the reader could imagine, the study encompasses many other implications. So, it would be pretentious to declare that the list presented here is exhaustive.

**Implication for a Pressing Professional Development in Technology Education**

UNESCO indicated, “No nation can afford to ignore the impact of technology on the modern world. Indeed the rapid advances made in all technical and industrial fields in recent decades have determined the very contours of contemporary civilization” (United Nations Educational, Scientific, and Cultural Organization [UNESCO], 1973, p. 11). Benin educational leaders, though aware of the impact of technology on today’s civilization when designing the *New Study Programs*, did not take into consideration an important component of a curriculum reform, which is the PD of teachers. Kerre (1990) insisted on that issue:

Given the present rate of acceleration of technological change and the emergence of high-level technologies, it is now believed that a good-quality basic education,
which also introduces the learners to basic concepts and skills of technology, is mandatory. The phase that will be emphasized at any level will depend on a national philosophy and the policy framework on technology education. However, the context for technology education cannot be adequately addressed without including the training component. (p. 42)

One implication of this study is then related to a pressing need of PD for teachers’ leaders and secondary school science teachers. On the one hand, teachers’ leaders, such as pedagogical advisors, should be trained in TE content knowledge, TE pedagogical content knowledge, and technological process in order to be able to successfully complete their job. Zannou (2004) found that, during the expansion of the new curriculum, teachers’ trainers lack TE expertise. Therefore, a PD is needed for these leaders. Subsequent to the training of these leaders is the reinforcement of their supervisory activities. The effectiveness of TE teaching and its impact on students’ achievement depend on a continuing control and monitory of teachers’ pedagogical tasks. Therefore, pedagogical advisors should conduct regular classroom visitations, to make sure that teachers are teaching TE lessons and make suggestions to teachers about innovative TE teaching strategies, and evaluate the level of teacher performance in TE teaching strategies.

On the other hand, because participating teachers evoked the need of replication of the TEPD program and its expansion to other teachers, a program like the TEPD program is needed for teachers. Finally, it is important to note that because of the evolving nature of TE, PD should not constitute a “one-shot” PD, but a continuous
process for change in teacher’s beliefs and attitudes. Indeed, “in successful programs and change efforts, professional development is not an event…. Rather [it] is an ongoing activity woven into the fabric of every educator’s professional life.” (Guskey, 2000)

*Implication for Benin Science Teachers’ Empowerment*

Reformers and practitioners alike embraced the concept of teachers’ empowerment as being fundamental to an enhanced sense of professionalism and, ultimately, to better teaching (Lichtenstein, Mclaughlin, & Knudsen, 1992). Participating teachers, through their journals and post-session evaluations, mentioned that they learned a lot and were able to teach their students and other teachers as well. Therefore, the TEPD program empowered these teachers, and they took ownership of the program and resolutely decided to distribute their knowledge to their students and peers. Teachers understood the significance of the TE portion included in the *New Study Programs*. They realized that TE is not an imported topic that was imposed to them, but a subject people are used to and are dealing with, and that Benin educational leaders wanted to develop in students.

Therefore, an implication for this study is to give autonomy, responsibility, choice and authority to teachers while implementing the curriculum. As they appreciated that TE is not the privilege of only developed countries, but is also integrated in our everyday lives; as they recognized that before the colonization period, Benin people’s ancestors were producing their own instruments and tools, and that nowadays, everywhere, students are dealing with TE, teachers should be empowered to take a step while teaching the TE in their school. As has been stated, “empowering teachers most commonly appears to
refer to ‘allowing’ classroom teachers to participate more directly in their schools’
decision making” (Mckenzie, 1989).

**Implications for Benin Education**

Conscious of the importance of technology in people’s lives, Benin educational
leaders designed an interesting physical science curriculum incorporating TE. This
curriculum is considered an Africanized curriculum, as it incorporated “both indigenous
knowledge and traditions and current ideas and knowledge representing widespread
educational theory and practice” (Sunal, 1998, p. 223). However, the implementation
phase of this curriculum failed, because teachers were not trained to effectively teach it.
Therefore, one implication for this study is that Benin education leaders should take
advantage of the TEPD program, greatly appreciated by the participants, to extend
teachers’ training all over the country in order to improve students’ learning.
Undoubtedly, that executives or decision-makers in the Ministry of Primary and
Secondary Education, major educational institutions and curriculum headquarters in the
capital city, received a complimentary feedback of the program and could contact the
researcher, who would be more than happy to share his expertise.

**Implication for Benin Economic Future and Sustainability**

General orientations of the *New Study Programs*, which is a competency-based
curriculum, stipulated, “We must create in Benin courageous and dynamic elite,
intellectually prepared to face the problems of the new millennium, capable to propose
new ideas, to positively influence the young generation. We must encourage effort,
develop creativity, and promote invention” (MENRS, 1990, p. 15). In addition, political,
epistemological, psychological, philosophical, socio-economic and cultural foundations of the *New Study Programs* underlined the significance of teaching TE and its role for Benin economic development and for our students’ cultural identity. Therefore, the TEPD program should be spread to other teachers in the country and be replicated every year, because teachers understood that teaching TE to students is important and could be both a factor to boost Benin economic development and promote cultural self-identity.

*Implication for a Transformative Curriculum Evaluation*

Without carrying out a critical analysis of the TE portion of curriculum, the researcher wanted to suggest an evaluation of the present curriculum that could be called a transformative curriculum evaluation. Participants indicated that the liquid thermometer, which was one of the artifacts included in the TEPD program and also in the *New Study Programs*, was not easy to design and to make. They stated that this proposed artifact did not take into consideration contextual realities. This observation posed the problem of the “top-down” curriculum designed by curriculum leaders. Benin’s education system is based on high level of financial, administrative, and pedagogical centralization. Every aspect of schooling – aims, objectives, instruction, courses, hours, teacher training, textbooks, and assessment – is state-controlled. This mainstream colonial-type of curriculum control disempowers teachers, impedes their professional growth, devalues the teaching profession, and conflicts with the democratic orientation of the country. Therefore, an implication of the study is the curriculum evaluation that is transformative in nature, democratic in principle and emancipatory in character (Henderson & Hawthorne, 2000). This implies the banishment of the colonial-type of
designing the curriculum, and the involvement and collaboration of curriculum leaders, teacher’s leaders, representatives of teachers, and other school stakeholders in the design and the evaluation of the TE part of the curriculum, which would integrate practical and meaningful artifacts to be made.

*Implication for the Procurement of Teaching Materials*

Even though directives for making the artifacts included in the curriculum guides are related to the use of everyday recyclable materials, other supplies such as cutters, LED, electric connectors, bulb lights, knives, burners, batteries, etc. are still needed. When the researcher presented the different materials for making artifacts to be used during the TEPD sessions, all participants indicated that their school could not afford such materials. A prevailing challenge to curricular change in science in developing countries is often “the shortage and/or lack of resources such as facilities, learning materials, and qualified teachers” (Kerre, 1990). Also, the paradigm shift from teacher-center to learner-center and the development of new competencies, which are the basis of the *New Study Programs*, requires appropriate textbooks, workbooks, teaching guides, and activity books. As a former high school physical science teacher and a pedagogical advisor, the researcher is aware of these crucial situations in Benin education. Even though teachers are not eager to teach the TE part of the science curriculum because of their lack of background knowledge for the subject matter, another fundamental reason of this unwillingness is the absence of materials for performing hands-on activities with students. Therefore, an implication of this study is the consciousness-raising of governmental agencies, the Ministry of Primary and Secondary Education, and school
principals to provide science teachers with a minimum of funding or teaching materials to improve their working conditions for a successful TE teaching.

**Implication for Meaningful Incentives in Professional Development**

One of the hidden characteristics of an effective PD is the provision of incentives. There is no doubt that attending a PD has many advantages for teachers and, in the long run, for the whole education system. The advantages include teachers’ content and pedagogical learning, innovative teaching strategies for students’ learning, classroom management performance, students’ achievements, etc. Bell and Gilbert (1996) indicated that an area of interest for some teachers seeking PD is “increasing and updating subject knowledge, and preparing the subject knowledge for teaching and learning activities” (p. 6). In addition to these instructional advantages, teachers benefit from other incentives such as logistics, certification, and salary increase.

Although all participants acknowledged the effectiveness of the TEPD program, many teachers’ defections were noticed. An informal inquiry revealed that, in addition to gaining knowledge and skills required to improve their teaching, teachers need other compensations. Teachers usually ask what tangible benefit they would get after receiving the training, other than increased teaching skills (Gidey, 2002). Many participating teachers are of the opinion that PD and other teacher trainings should be linked to their future career development. Therefore, in addition to allocating logistics, such as honorariums during teacher PD, educational policy makers in Benin should think about other meaningful inducements, such as certification after the PD program and salary augmentation. In developed countries such as the United States, teachers have their
salary increased after taking university credits or participating in PD. Policy makers in developing countries should decide such compensation to encourage teachers’ willingness to learn for the betterment of their teaching.

**Implication for Designing Assessment Tools in Technology Education**

A great shortcoming of the *New Study Programs* is the lack of assessment strategies for students’ works. Aware of that situation, the researcher, along with participating teachers, designed rubrics, which allowed them to evaluate some teachers’ artifacts. The observed teachers utilized those rubrics to judge their students’ artifacts. Consequently, it urges that curriculum leaders provide secondary school science teachers with assessment strategies to help the latter evaluate students’ works. Welch (2007) warns that assessment in TE is complex because it addresses students’ capability. He goes on to say, “To assess capability is complex because we are looking for a whole that is more than the sum of its constituent parts, much more that displaying knowledge, or understanding, or manual skills” (p. 3). A good job was done during the implementation of the TEPD program regarding the design of the assessment rubrics; it is suggested that curriculum leaders could take ownership and officially recognize those rubrics in order to alleviate teachers’ job in terms of assessment of students’ works.

**Implication for Integrating Technology Education in Teacher Education Program**

The lack of background knowledge in TE is one of the reasons for secondary school science teachers’ reluctance to teach the TE portion of the new curriculum. Participating in a PD program, particularly in an ongoing PD, is interesting, however, learning the content and the pedagogical content during teacher preparation is important.
A PD could help a teacher update his knowledge of the subject matter and learn new teaching strategies. But, during teacher preparation, a student teacher learns more in-depth the content of the subject and other related teaching strategies and skills. African countries, especially Benin, face teacher preparation problems with regard to curriculum reform. When throughout the continent there is an “africanization” of curricula in order to get rid of the colonial-type of curriculum, the preparation of teachers remains a great concern. Fafunwa (1967) underlined this issue:

Of all the educational problems that beset the African countries today, none is as persistent or as compelling as the one relating to the training of a competent teacher. The demands for more and better schools in all parts of the continent; the need to relate the curriculum to the child’s environment; the need for appropriate text-books and other instructional materials; …and indeed the over-all problem of preparing future citizens of Africa who will be fully oriented to their environment cannot be effectively accomplished without the aid of competent teachers. (p. 82)

Thus, an implication for this study is, on the one hand, the preparation of student teachers to effectively teach TE. This calls for the integration of TE courses in the teacher education program. The teacher education program should integrate the teaching of topics in TE, such as the history of TE, relationships between science and TE, the significance of teaching TE in schools, and the use of TE in the society. On the other hand, it is important for teacher educators to consider the beliefs of their students and work in order to change those beliefs, when designing and implementing courses, workshops, and field
experiences because “just as teachers hold beliefs, beliefs hold teachers.” (Bullough & Baughman, 1997)

Implication for a Holistic Technology Education Teaching

In the scope of the TE curriculum evaluation and TE integration in the teacher education program, it is suggested that curriculum leaders in Benin, as well as teacher educators, aim for a holistic understanding of TE. Indeed, one of the objectives of the New Study Programs is to prepare students to be responsible, self-sufficient, lifelong learners with high creativity, capabilities to solve current life problems, and the ability to construct their own knowledge. These aptitudes were perceived by many as contributing to the cultivation of a culture of peace for a democratic way of living.

Therefore, technology educators should “be holistic in the understanding conveyed to learners of technology itself in order to make better informed technical and design decision in a wider range of applied settings” (Seemann, 2003, p. 28). “In philosophy, the holist position asserts that to understand the particular, one must understand its relation to the whole, and that only through reflection that one’s sensation based applications can genuine knowledge be critically affirmed” (Mattews 1980, p. 87 & p. 93). Technology teachers should then know some basic principles in order to determine what to include in lessons and evaluations to ensure reasonable holistic coverage of any technical education. Seemann advised that TE and practice are not only a “how-to” experience, but also significantly a “know-why” experience, because the latter “is fundamental to the human act of creating new knowledge itself, not just using knowledge” (p. 30).
Recommendations for Further Research

The domain of research in education remains untouched in Benin, meaning, in the field of education, many inquiries linger to be investigated. Because of its unique nature, this study raises other questioning concerns with reference to (1) a replication of the study, (2) the design of self-efficacy instrument in TE, (3) the redesign of the TE Awareness instrument, (4) the impacts of TE teaching on students’ achievement, and finally (5) teacher action research study.

Recommendation of a Replication of the Study

It has been pointed out that limitations of this study include time restriction, the number of TEPD sessions delivered, the sampling procedure, and the pre-experimental research design. Moreover, the quantitative descriptive results indicated that teachers’ self-efficacy beliefs were not enhanced after participating in the program. Consequently, further study conducted with no time restriction and an experimental research design with a bigger sample and using a multivariate t-test – which is more accurate than the dependent paired-samples t-test – would generate teachers’ self-efficacy enhancement and would allow greater generalization.

Recommendation for Designing a Self-Efficacy Instrument in Technology Education

Teachers’ self-efficacy is an important concept in social cognitive theory and in education as well. Many instruments using a variety of efficacy scales are used in research. In spite of the measurement confusion, teacher efficacy still emerged as a worthy variable in educational research (Henson, 2001). The science teaching efficacy
belief (STEBI) form-A has been adopted to investigate teachers’ self-efficacy in many subject matters. Further study would generate the validity and reliability of the teacher education teacher efficacy belief instrument (TETEBI) used in the scope of this study for its adoption in TE area.

 Recommendation for the Redesign of the Technology Education Awareness Instrument

Another limitation of this study pertains to the design of the technology education awareness instrument (TE Awareness). Albeit this instrument encompasses three sections, including science and technology, technology, and technology education, there still remain some shortcomings. A research study would redesign that instrument, taking into account other factors related to TE, and conducting its reliability and validity to allow its use in the field of TE.

 Recommendation for the Impacts of Technology Education Teaching on Students’ Achievement

Students’ interviews carried out after classroom observations were to investigate whether or not students understood the objectives of the lessons and the extent to which they comprehended the technological process. The study was not designed to investigate the effects of TE on secondary school students; therefore, further study using an experimental research design might explore impacts of TE teaching on students’ achievements in the classroom. Moreover, TE being a new portion that was integrated in the science curriculum, it offers teachers and other researchers an unexplored field of research related. Finally, a longitudinal study on impacts of TE teaching on students’
achievement might generate data that could help demonstrate the effectiveness of the
New Study Programs.

Recommendation for Teacher Action Research in Technology Education

Action research implies an orientation to research, a form of professional practice, a research process, and, for teachers, a reflective way of teaching (Holly, Arhar, & Kasten, 2005). Teachers are not accustomed to carrying out research in secondary school settings, especially an action research study. The last recommendation of this study is to urge teachers to conduct action research when teaching TE in their classroom in order to investigate ways and means to improve their practice and to help students learn. As Danielson (2002) advised it: “Educators cannot sit back and wait for others to act. They must do what they can do – namely, ensure that every child who enters school leaves with a solid education and the skills and confidence to do something with it” (p. xiv).

Concluding Comments

Two major purposes guided this study. The practical purpose of the study was to provide Benin secondary school teachers with an effective TEPD program. The research purpose of the study was to explore teachers’ self-efficacy beliefs to teach the TE portion of the curriculum, the TE content knowledge, the TE pedagogical content knowledge, and teachers’ perceptions after participating in the PD designed to assist them. At the beginning of this study, the researcher laid out an explicit statement of what should be considered as the problematic situation that needed exploration. Mixed methods research design was used to collect data. After data collection, the theoretical framework that was used in the study, facilitated data analysis, and helped organize the description and
discussion of the major themes. The salient results of the study indicated that (1) the TEPD program was effective; (2) although descriptive quantitative analysis was inconclusive, through teachers’ journals and post-session evaluations, their self-efficacy beliefs were enhanced after participating in the program; (3) teachers did acquire TE content knowledge and pedagogical content knowledge; (4) teachers were teaching the TE lessons integrated in the science curriculum; and, (5) teachers expressed positive perceptions about the program and acknowledged its soundness, relevancy and effectiveness. Educational implications linked to the description and analysis of data was provided and recommendations for further research were made. However, the researcher pointed out that readers might be able to infer other interpretations from the data and generate specific implications that will bring meaningful information to curriculum developers and stimulate educational research in Benin.

Finally, in the following lines, the pronoun “I” will be used instead of the impersonal expression of “the researcher,” as it is easier to use and as I wanted to deliberate on my options for my dissertation research. These deliberations are inspired by my journey through the graduate programs and related to what Pinar (2004) called “complicated conversation.” According to Pinar:

“Complicated conversation” is the central concept in contemporary curriculum studies in the United States. It is the idea that keeps hope alive, enabling us to have faith in which we – both education professors and public-school teachers – determine the curriculum, both in the university and in the public schools. (p. xii)
Integrating TE in the secondary school science curriculum is a great curriculum reform that Benin educational leaders have ever done, due to its importance in the 21st century civilization. This curriculum change means a big change for teachers and mostly for students. As usual in developing countries, especially in Benin, teachers’ trainings with regard to the reform remain a big concern. Then, I decided to help teachers succeed in their practice. Dealing with my study, I inscribed several methodological forms of scholarship.

Action research scholar is the first form of scholarship that I exhibited throughout this research study. Implementing the TEPD program was for me a way to increase my understanding of what is PD, and create explanations that could inform the practice of PD. I think that one of the goals of action research is that “education professors must make themselves available to other members of the education professions and to parents and students, to support the struggle to sustain educational values in a word increasingly beset by economic and other forms of fundamentalism” (McTaggart, 2002, p. 14). I believe that there is a need to understand the challenges facing career classroom teachers. With this in mind, the second form of methodological form of scholarship that I demonstrated is the conceptual scholar. In education, the literature usually refers to “theory into practice,” meaning that practice is to be guided by theory. That is why in my dissertation, it is recommended that teachers learn first a variety of theoretical constructs related to TE before going before students, because theory provides rational foundations for practice. Dealing with the whole process of dissertation research, it is obvious that I am a practitioner scholar. I believe that teaching is more than vocation; it is a calling.
Teachers should know perfectly their profession in order to deserve respect and confidence from parents and students. Designing and implementing the TEPD program to assist teachers, my belief is that one of the teachers’ goals when accomplishing their job should be rigorous knowledge. Throughout this research study process, my trait as critical scholar was put forward. Ever since I decided to teach, critical consciousness or critical awareness, teaching for a democratic way of living, and curriculum contextualization, have been and are my motto. I believe that teachers should reflect on their teaching, think what it is to be a teacher, and reflect on their role in the development of the country. The three main elements of engaging teachers in “critical reflection” are (a) narrative or text; (b) dialogue; and (c) theory building – all of which act in concert to produce pedagogical change and “political action” (Smith, 2002, p. 71). Through the holistic TE teaching, teachers have the role to raise students’ consciousness and to help them understand that TE is the only way out from their situation of being underdeveloped. Finally, like any other researcher, I believe that I am a spiritual scholar. This methodological form of scholarship has continually been in the heart of my studies, my teaching job and in my research study. My overall goal as a researcher has been to help teachers succeed in their job. The practical research purpose of my dissertation is an example of that objective. I believe that spirituality is embedded in a scholar’s life, as Palmer (1994) put it:

> We live in and through a complex interaction of spirit and matter, a complex interaction of what is inside of us and what is “out there.” The wisdom of our spiritual tradition is not to deny the reality of the outer world, but to help us
understand that we create the world, in part by projecting our spirit on it – for the better or worse. (p. 23)

I believe that, with spirituality, scholars are creating with their perpetual work the world for the upcoming generations.
APPENDIXES
APPENDIX A
CONSENT FORM

A. Explanatory Text

Project Title: *A Professional Development Study of Technology Education in Secondary Science Teaching in Benin: Issues of Teacher change and Self-efficacy Beliefs*

The practical purpose of the study is to provide Benin middle school teachers with an effective technology education (TE) professional development, which would grant teachers with four different experiences. The research purpose of the study is to explore these teachers’ self-efficacy beliefs to teach the TE part of the curriculum after attending the professional development. The researcher’s research purpose is led by his motivation to develop an understanding of factors enhancing teachers’ self-efficacy to teach TE to students and allowing them to teach new topics. If you decide to participate in this project, you will be asked to serve, along with the researcher, in a committee which role is to perform class observations and a 30-min discussion related to the observations in the presence of the observed teacher. Your participation to the study does not involve any discomfort or risk. Your name will not appear on the research report. I will only use pseudonyms to identify you.

If you take part in this project, there is no financial benefit expected to be gained: this project is an academic exercise which is aimed at demonstrating my ability to do research as a doctoral candidate for the purpose of a dissertation. Taking part in this project is entirely up to you, and no one will hold it against you if decide not to do it. If you do take part, you may stop at any time.

If you want more information about this project, please call me at (229) 20 24 50 40 (Benin) (e-mail: rkelani@kent.edu) or you can call my advisors Dr. Claudia Khourey-Bowers and Dr. Kenneth Cushner at 330-672-0728 (e-mail: kcushner@kent.edu). The project has been approved by Kent State University. If you have questions about Kent State University’s rules for research, please call Dr. John L. West, Vice President for Research, and Dean of Graduate Studies at (330) 672-2851 (e-mail: jlwest@kent.edu).

You will get a copy of this consent form.

Sincerely,
Raphael Kelani, Graduate Student in Curriculum and Instruction

B. Consent Statement(s)

I agree to take part in this project. I know what I will have to do and that I can stop at any time.

Signature  Date
APPENDIX B
Dear Teacher,

I wanted to thank you for accepting to answer this questionnaire. The purpose of this investigation is to gain a general idea about the degree of teachers’ self-efficacy in teaching technology education to secondary school (premier cycle) students. In case you have questions relating to this research, please contact the researcher Raphael Kelani:

Phone: Home: (229) 20 24 50 40 or Mobile: (229) 95 25 16 30
Email: rkelani@kent.edu or rkelani@yahoo.fr
Post office: 01 BP 506 Porto-Novo (Rep. of Benin)

There is no write or wrong answers to the 25 statements below. Please indicate the degree to which you agree or disagree with each statement by choosing (Make a cross) only an answer by statement using the scale below:
SA = Strongly Agree; A = Agree; UN = Uncertain; D = Disagree; SD = Strongly Disagree.

<table>
<thead>
<tr>
<th>No.</th>
<th>Statement</th>
<th>SA</th>
<th>A</th>
<th>UN</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>When a student does better than usual in technology education, it is often because the teacher exerted a little extra effort.</td>
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<td>2</td>
<td>I am continually finding better ways to teach technology education.</td>
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<td>3</td>
<td>Even when I try very hard, I don’t teach technology education as well as I do most chapters.</td>
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<td>4</td>
<td>When the technology education grades of students improve, it is because often due to their teacher having found a more effective teaching approach.</td>
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<td>5</td>
<td>I know the steps necessary to teach technology education concepts effectively.</td>
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<td>6</td>
<td>I am not very effective in monitoring technology education activities</td>
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<td>7</td>
<td>If students are underachieving in technology education, it is most likely due to ineffective technology education teaching.</td>
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<td>8</td>
<td>I generally teach technology education ineffectively.</td>
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<td>9</td>
<td>The inadequacy of a student’s technology education background can be overcome by good teaching.</td>
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<td>10</td>
<td>The low technology education achievement of some students cannot generally be blamed on their teachers.</td>
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<td>11</td>
<td>When a low achieving child progresses in technology education, it is usually due to extra attention given by the teacher.</td>
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<td>12</td>
<td>I understand technology education concepts well enough to be effective in teaching middle school technology education.</td>
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<td>13</td>
<td>Increased effort in technology education teaching produces little change in some students’ technology education achievement.</td>
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<td>14</td>
<td>The teacher is generally responsible for the achievement of students in technology education.</td>
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<td>15</td>
<td>Students’ achievement in technology education is directly related to their teacher’s effectiveness in technology education teaching.</td>
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<td>16</td>
<td>If parents comment that their child is showing more interest in technology education at school, it is probably due to the performance of the child’s teacher.</td>
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<td>17</td>
<td>I find it difficult to explain to students why technology education works</td>
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<td>18</td>
<td>I am typically able to answer students’ technology education questions.</td>
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<td>19</td>
<td>I wonder if I have the necessary skills to teach technology education.</td>
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<td>20</td>
<td>Effectiveness in technology education teaching has little influence on the achievement of students with low motivation.</td>
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<td>21</td>
<td>Given a choice, I would not invite the principal to evaluate my technology education teaching.</td>
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<td>22</td>
<td>When a student has difficulty understanding a technology education concept, I am usually at a loss as to how to help the student understand it better.</td>
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<td>23</td>
<td>When teaching technology education, I usually welcome student questions.</td>
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<td>24</td>
<td>I don’t know what to do to turn students on to technology education.</td>
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<td>25</td>
<td>Even teachers with good technology education teaching abilities cannot help some kids learn technology education.</td>
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</table>
APPENDIX C
Dear Teacher,

Far from being a test, this questionnaire hopes to probe your knowledge in technology education at the middle school level in Benin. While providing me with the below information, I formally guarantee you that neither your name nor the one of your school will be revealed. Thank you in advance for objectively answering this questionnaire.

I. Statistical Information

Name: ______________________________________________________________

Age: __________

Gender: ___ Male                      ___ Female

Academic Diploma:

_____ BAC; _____ DUES; _____ Bachelor Degree; _____ Master

_____ Other (To be specified) ______________________________________________

Teaching Certificate:

_____ BAPES; _____ CAPES; _____ Other (To be specified) ____________________

Number of Technology Education courses: ______________

Number of Professional Development in Technology Education you have taken? ______

Number of years of teaching: ______

Number of classes you teach: ________           Total number of students: _________

II. Statements

Please indicate, whether each statement below is true (T) or false (F).

<table>
<thead>
<tr>
<th>No</th>
<th>Statement</th>
<th>T</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>There is a difference between science and technology</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
There is interaction between science and technology.

Scientifics and technologists work hand in hand.

One cannot teach science without technology.

Science precedes technology.

Science and technology are independent.

Like science, there are several approaches to teach technology.

Science and technology have an effect on the way life of the family.

Science and technology have an effect on the development of a country.

<table>
<thead>
<tr>
<th>No</th>
<th>Technology</th>
<th>T</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Technology mainly concerns computers and similar equipment.</td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>Making models and testing them is part of technology</td>
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<tr>
<td>3</td>
<td>Working with materials is an important part of technology.</td>
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<td>4</td>
<td>Technology involves designing solutions to problems.</td>
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<td>5</td>
<td>Most people have little to do with technology in their everyday lives.</td>
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<tr>
<td>6</td>
<td>In technology there are opportunities to design new products.</td>
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<tr>
<td>7</td>
<td>Two hundred years ago there was no technology.</td>
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<tr>
<td>8</td>
<td>Technology means inventing new ways of doing things.</td>
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</table>

<table>
<thead>
<tr>
<th>No</th>
<th>Technology Education</th>
<th>T</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Technology education is a course based on the fact that technology is a discipline participating to the learner’s general training in the same way as the traditional disciplines.</td>
<td></td>
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<tr>
<td>2</td>
<td>The competency-based curriculum favored the process of resolution of situations-problems in teaching technology education courses.</td>
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<tr>
<td>3</td>
<td>The technological process of design stimulates the learner to conceive, evaluate, and to re-conceive solution to problems.</td>
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<tr>
<td>4</td>
<td>One of the pedagogical objectives of technology education is to offer opportunities for the learners to develop their problem solving capacities.</td>
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<tr>
<td>5</td>
<td>There are six steps in the technological processes of making a n artifact.</td>
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<tr>
<td>6</td>
<td>There are at least three specific competencies to be developed in technology education.</td>
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</tbody>
</table>
GENERIC CONSENT FORM

A. Explanatory Text

Project Title: A Professional Development Study of Technology Education in Secondary Science Teaching in Benin: Issues of Teacher change and Self-efficacy Beliefs.

The practical purpose of the study is to provide Benin middle school science teachers with an effective technology education (TE) professional development, which would grant teachers with four different experiences. The research purpose of the study is to explore these teachers’ self-efficacy beliefs to teach the TE part of the curriculum after attending the professional development. The researcher’s research purpose is led by his motivation to develop an understanding of factors enhancing teachers’ self-efficacy to teach TE to students and allowing them to teach new topics. If you decide to participate in this project, you will receive two surveys with 25 statements, one before and the other after attending six sessions of training, at the rate of one a week, and be asked to rate the extent to which you agree or disagree with each statement. Rating the survey will take approximately 15 min. You will be asked to complete an evaluation sheet after each session and to submit a weekly journal via e-mail to the researcher. You may be interviewed during approximately 15 min related to the training activities. I may also come to your class, along with a committee, to observe one time your teaching of a TE lesson related to a part of a subject taught during the training, and have an after class 30-min discussion with you. Your participation to the study does not involve any discomfort or risk.

Your name and school will not appear on the research report. I will only use pseudonyms to identify you, your students, and your school.

If you and your students take part in this project, there is no financial benefit expected to be gained: this project is an academic exercise which is aimed at demonstrating my ability to do research as a doctoral candidate for the purpose of a dissertation. Taking part in this project is entirely up to you, and no one will hold it against you if decide not to do it. If you do take part, you may stop at any time.

If you want more information about this project, please call me at (229) 20 24 50 40 (Benin) (e-mail: rkelani@kent.edu) or you can call my advisors Dr. Claudia Khourey-Bowers and Dr. Kenneth Cushner at (330)672-0728 (e-mail: kcushner@kent.edu). The project has been approved by Kent State University. If you have questions about Kent State University’s rules for research, please call Dr. John L. West, Vice President for Research, and Dean of Graduate Studies at (330) 672-2851 (e-mail: jlwest@kent.edu).

You will get a copy of this consent form.

Sincerely,

Raphael Kelani, Graduate Student in Curriculum and Instruction

B. Consent Statement(s)

I agree to take part and let my students take part in this project. I know what I will have to do and that I can stop at any time.

______________________________________  ____________________________
Signature                                      Date

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Questions for Journal

Session One

Dear Teacher,

Please, answer as thoroughly as possible the following questions in your journal. This should be turned in at the beginning of the next session.

Thanks

1. Reflecting over the whole *New Study Programs* and the technology education (TE) portion in the science curriculum, do you think that teaching TE is important to students? If yes, why? If not, why not?

2. a) Explain how are you teaching TE in your classroom?

   b) How are you making students design artifacts?

   c) What challenges do you encounter when teaching TE in your classroom?

3. Do you think that the way students are taught help them to be as skilled as possible to face society’s challenges? If yes, why? If not, why not?

4. What did you find the most useful in the TEPD session this week?

Session Two

Dear Teacher,

Please, answer as thoroughly as possible the following questions in your journal. This should be turned in at the beginning of the next session.

Thanks
1. What are the challenges encountered while designing the different artifacts during the professional development?

2. What surprised you while attending the TEPD program? Please explain.

3. What did you find the most useful in the TEPD session this week?

4. How will this PD potentially impact your classroom teaching of TE?

5. What suggestions do you have to improve the activities of this workshop?

Session Three

Dear Teacher,

Please, answer as thoroughly as possible the following questions in your journal. This should be turned in at the beginning of the next session.

Thanks

1. What are the challenges encountered while designing the different artifacts during the professional development?

2. What did you find the most useful in the TEPD session this week?

3. How will this PD potentially impact your understanding of TE and classroom teaching of TE?

4. What suggestions do you have to improve the workshop?

Session Four

Dear Teacher,

Please, answer as thoroughly as possible the following questions in your journal. This should be turned in at the end of this session.

Thanks
1. Did the present workshop meet your expectations? Please explain.

2. a) Do the TEPD sessions help you understand more TE and how to teach it? Please explain.

   b) Describe any changes in your way of teaching after participating in this program.

3. What are your impressions regarding the organizations of the TEPD program and the instructors’ works?

4. What is the most significant thing you learned about TE and teaching TE?

5. How would you describe your participation to this program?

6. Overall, what did you learn from the program?

7. What would you like as the next step following this PD? Other suggestions?
Dear Teacher,

Thank you for participating in today’s session. This little questionnaire is intended to check your understanding of the session and whether or not changes are needed to improve upcoming sessions. You can continue writing on the back if necessary.

1. What did you learn today? ______________________________________________

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. What was the best part of today’s session? ________________________________

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

3. What question(s) do you have about today’s topic? _______________________

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4. Other comments? _____________________________________________________

________________________________________________________________________
________________________________________________________________________
Technology Education Class Observation Rubrics

Background Information

Date: _________________________  School: _____________________________
Starting Time: __________________  End Time: ___________________________
Grade: ________________________  Total Number of Students: ______________
Observer: ______________________  Qualification; ________________________
Teacher Name: _________________________________________________________
Qualification ___________________  Length of Service: ____________________
Lesson’s Topic: _________________________________________________________

Observation Instrument

At the time of the observation of the lesson, in order to reply to each question, the observer is required to mark one of the available boxes, using the codes below:

1 = Very Well or Yes
2 = Well or Sufficiently Well
3 = Well Enough or Sufficiently
4 = Unacceptable or Insufficient
5 = Null or No

<table>
<thead>
<tr>
<th>STATE OF THE CLASS</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td>No 1 Is the class well lighted?</td>
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<td>No 2 Is the class well ventilated?</td>
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<td>No 3 Is there sufficient furniture in the class?</td>
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<td>No 4 Do the number of students in the class allow for a good constitution of small groups?</td>
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<td>No 5 Are tables well displayed for students’ constitution of small groups?</td>
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</table>

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<table>
<thead>
<tr>
<th>No</th>
<th>ITEM</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td>6</td>
<td>Did the motivation created by the teacher mobilize learners’ attention?</td>
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<td>7</td>
<td>Did the lesson’s topic carry on learners’ interest?</td>
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<td>8</td>
<td>Was the situation-problem clarified?</td>
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<td>9</td>
<td>Did the teacher provoke learners’ comprehension of the situation-problem?</td>
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<td>10</td>
<td>Does the teacher accept learners’ proposed reformulation of the situation-problem?</td>
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<td>11</td>
<td>Does the teacher grant full attention to learners’ interventions?</td>
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<td>12</td>
<td>Did the teacher have adequate content knowledge of his subject matter?</td>
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<td>13</td>
<td>Did the teacher have adequate pedagogical content knowledge of his subject matter?</td>
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<td>14</td>
<td>Did the teacher have adequate evaluation knowledge of his subject matter?</td>
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<td>15</td>
<td>Is the teacher comfortable to answer all requests of information from learners?</td>
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<td>16</td>
<td>Is the available equipment useful for this technology education course?</td>
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<td>17</td>
<td>Is this equipment sufficient?</td>
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<td>18</td>
<td>Does the teacher know how to use it?</td>
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<td>19</td>
<td>Does the teacher possess a mastery of directing the experience proposed to learners?</td>
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<td>20</td>
<td>Does the teacher possess a mastery of the technological process?</td>
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<td>21</td>
<td>Does the teacher help the learners take ownership of the technological process?</td>
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<td>22</td>
<td>Did the evaluation of learners’ gained knowledge during this teaching/apprenticeship take place?</td>
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<td>23</td>
<td>Does the evaluation focus on different aspects of technological realization?</td>
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<td>24</td>
<td>Does the evaluation focus on the learner’s apprenticeship strategies during his/her activity?</td>
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<td>25</td>
<td>Are the evaluation criteria understandable?</td>
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<td>26</td>
<td>Are the evaluation criteria unambiguous?</td>
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APPENDIX H
AUDIO/VIDEOTAPE CONSENT FORM

Project Title: *A Professional Development Study of Technology Education in Secondary Science Teaching in Benin: Issues of Teacher change and Self-efficacy Beliefs.*

I agree to audio and video taping

at ____________________________
on __________________________


Signature                                                                 Date

I have been told that I have the right to hear and see the audiotapes before they are used. I have decided that I:

_____ want to hear and see the tapes    _____ do not want to hear and see the tapes.

Sign now below if you do not want to hear and see the tapes. If you want to hear and see the tapes, you will be asked to sign after hearing them.

The original tapes or copies may be used for:

_____ this research project _____ teacher education—— presentation at professional meetings.


Signature                                                                 Date

Address:
REFERENCES


conference of the mathematics education research group of Australasia (pp. 153-164). Lismore, NSW: Southern Cross University.


http://www.tki.org.nzcurriculum/whats_happening/index_e.php


http://www.ibstp.org/competencies.htm


http://scholar.lib.vt.edu/ejournals/JOTS/Summer-Fall-1999/Loepp.html


