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## Teacher Change Facilitated By Sustained School Situated Professional Development: Exemplar Learning Of Technology Enhanced Formative Assessment (TEFA)

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**TEACHER CHANGE FACILITATED BY SUSTAINED SCHOOL SITUATED  
PROFESSIONAL DEVELOPMENT: EXEMPLAR LEARNING OF  
TECHNOLOGY ENHANCED FORMATIVE ASSESSMENT (TEFA)**

A Dissertation Presented

by

KAREN ST. CYR

Submitted to the Graduate School of the  
University of Massachusetts Amherst in partial fulfillment  
of the requirements for the degree of

DOCTOR OF EDUCATION

February 2009

Education

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Approved as to style and content by:

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Allan Feldman, Chair

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William Gerace, Member

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Florence Sullivan, Member

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Christine B. McCormick, Dean  
School of Education

## **DEDICATION**

To the all powerful God, Jehovah in appreciation for your grace that sustained me and brought me through.

## ACKNOWLEDGEMENTS

I wish to thank my devoted husband Leon for his love, support and encouragement and to thank my children, Rinaldo, Dario, Leonette and Kayliesha who continually inspire me. This dissertation is your work as much as it is mine. Special commendations to my mother, Barbara Dean, an educator extraordinaire, who taught me to never give up and who continues to defy the odds and my father Javan Dean who has been a tower of strength. My siblings, other family members and my friends, thank you for your encouragement and for being my fan club.

I am eternally grateful to the Organization of American States for awarding me the fellowship that made my matriculation at this great institution of excellence possible.

Special commendations to my advisor Professor Allan Feldman for your guidance and your insight in my formative development as a doctoral candidate, as a researcher, as an educator and for your contributions to my research. I am grateful to the other members of my committee, Professor William Gerace and Professor Florence Sullivan for your assistance, support and insightful comments.

I extend my gratitude to the other members of the TEFA team, Professor Ian Beatty, Professor William Leonard and my fellow research assistants Hyunju Lee and Robbie Harris for your collaborative support, assistance and for genuinely caring about me. Special thanks to Hyunju for your work and contribution to my analysis of the Teacher Monthly Reflection (TMR) Survey and to Robbie for your work and contribution with the TEFA Classroom Observation Protocol (TCOP). I am grateful for the opportunity to work with all of you on the TEFA team. Special thanks to all teachers participating in the TEFA project who opened their classrooms and their hearts to me. Thanks also to all teachers that I have had the privilege to work with while at University of Massachusetts Amherst.

I am thankful for every professor at whose feet I have sat in my quest for knowledge, professional development and personal fulfillment. My experiences at the University of Massachusetts Amherst have been truly enriching, enlightening and rewarding. You have all made it worthwhile.

Special thanks to everyone in the Bahamas and in Massachusetts who kept me going with your prayers, support and kind thoughts. It is because of all of you, that I have accomplished my goals and achieved my dream of earning a doctorate degree.

On the wings of an eagle I will continue to rise!

## **ABSTRACT**

**TEACHER CHANGE FACILITATED BY SUSTAINED SCHOOL SITUATED  
PROFESSIONAL DEVELOPMENT: EXEMPLAR LEARNING OF TECHNOLOGY  
ENHANCED FORMATIVE ASSESSMENT (TEFA)**

**FEBRUARY 2008**

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This case study instantiates longitudinal change over a two year period by examining the role of School Situated Sustained Professional Development (SSSPD) on the evolution of the participant's practice. The participant was a secondary science teacher who emerged as an exemplar in integrating Technology Enhanced Formative Assessment (TEFA) pedagogy into her practice, which was facilitated by personal response systems (PRS). The research question was: What could be revealed about the impact of SSSPD by studying teacher learning of a teacher who emerged as an exemplar? The participant was one of ten teachers learning the TEFA pedagogy. Professional development (PD) that facilitates change in teachers' practice and that sustains those changes over time is critical. Findings were triangulated from seven quantitative and qualitative data sets including monthly surveys, lesson observations, journal entries, interviews and action research sessions. The major findings of the study were: 1) implementing TEFA led to changes in the participant's practice, and 2) the SSSPD model was instrumental in the participant learning how to implement TEFA. Findings also revealed changes in the participant's beliefs, teaching strategies and in her modification of TEFA. Eight elements of teacher change were identified which were used to develop the Elements of Teacher Change in Adoption of Pedagogy (ETCAP) model. Gaining a better understanding of the SSSPD model and its potential as an effective model for PD is dependent on proving its effectiveness in promoting teacher change and sustaining that change over time.

Key words: professional development, Technology Enhanced Formative Assessment, personal response systems, teacher change, teacher learning

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# **CHAPTER I**

## **ROLE AND IMPACT OF SSSPD ON TEACHER CHANGE**

### **A. Introduction**

Priority has been placed on the development of scientific and technological literacy in all countries because of their very crucial impact on economic growth, national security and sustainable development (US Department of Energy, 2008; Tayeb & Schneegans, 2005). Universities are a source of new generations of scientists and engineers and universities in the United States of America remain on the forefront of science education, research and innovation (US Department of Energy, 2008; Tayeb & Schneegans, 2005). However, there is great concern because too few undergraduate students in the United States are specializing in science and engineering and a substantial amount of students born outside the United States of America account for science and engineering degrees awarded by universities in the United States (Augustine, 2005; Tayeb & Schneegans, 2005).

It is imperative to address these concerns by increasing the supply of well trained scientists and engineers and one way of doing this is by increasing the proficiency of teachers in delivering instruction and ensuring that there are qualified teachers in every classroom (US Department of Energy, 2008; Augustine, 2005; Tayeb & Schneegans, 2005). Cognizant of the need to promote science and technological literacy, all levels of academia should be placing strong emphasis on improving and expanding their science programs so that they could be more effective and comprehensive (National Science Foundation, 2006b). For science programs to be improved and expanded, teachers'

content knowledge and skills have to be strengthened (National Science Foundation, 2006b; Loucks-Horsley, et al., 1998; Supovitz & Turner, 2000). Professional development is one of the methods used to strengthen and improve teachers' practice. In order for professional development (PD) to be effective, it should be designed to give teachers the theoretical, pedagogical and content-based framework essential for teachers to develop proficiency in delivering science instruction (Loucks-Horsley, et al., 1998; Supovitz & Turner, 2000). In addition to meeting this fundamental goal, there are other factors that need to be considered to ensure that participating teachers use the new knowledge and skills gained from PD activities to effectively change their practice and to ensure that the change in practice is sustained over time (Guskey, 1994, 2000, 2003; McChesney, 1998, Kohler, et al., 1997).

One of the most important factors is the quality of the learning experience and its ability to help teachers connect to and have a wider and deeper appreciation of future experiences (Dewey, 1929). It is imperative to identify, address and resolve any tensions and problems that teachers may experience when integrating new pedagogy so that teachers would be more amenable to adopting new pedagogy learned in PD (Leonard, et al., 2004; Beatty, et al, 2008; Eylon, Berger & Bagno, 2007; Taitelbaum, et al, 2007; Johnson, et al, 2007; King, 2007). Professional development that addresses these needs while providing necessary support could facilitate the successful adoption and internalization of new pedagogy so that it becomes an integral and long term part of teachers' practice (Fischer, et al., 2004; Johnson, et al., 2007; Eylan, et al., 2007, Taitelbaum, et al., 2007).

Literature (Goldhammer, 1980; Goldenberg & Gallimore, 1991; Loucks-

Horsley, et al., 1998; Supovitz & Turner, 2000; Guadelli, 2002; Irving, Sanalan & Shirley, 2008; Sanalan, Irving, Pape & Owens, 2008; Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006; Johnson, et al., 2006; Fischer et al, 2004) have illuminated an interface between the structure, support and the longevity of the professional program and the efficacy of the PD experience in facilitating the integration of new pedagogies into teachers' practice. Teacher PD programs that are underpinned by teachers learning in a structured, formative, collaborative environment with frequent meetings on their school campuses could be more efficacious in teacher learning of new knowledge and skills than PD models that do not have these qualities (Irving, Sanalan & Shirley, 2008; Sanalan, Irving, Pape & Owens, 2008; Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006; Johnson, et al., 2006; Fischer et al, 2004). These qualities are inherent in the School Situated Sustained Professional Development (SSSPD) model to be studied in this research (Leonard, et al., 2004). It is anticipated that the findings from this research would provide insights on the dynamics of the teacher change and the impact of a SSSPD model on teacher learning of new pedagogy.

## **B. The Problem**

Disparity exists between the achievement of various groups of students in science. Professional development of teachers has been promoted as one of the solutions with the greatest impact in addressing these disparities in science achievement (NSF Science and Engineering Indicators, 2006a, 2006b). Many models of PD have been implemented but the disparities in science achievement still exist (NSF Science and Engineering Indicators, 2006a, 2006b). Student under achievement in science suggests

that more effort is needed in implementing PD that improves the teaching of science and thereby improve students' learning of science (NSF Science and Engineering Indicators, 2006a, 2006b).

There are numerous PD models with varying degrees of success that have been scrutinized by research. There has also been research in which various types and aspects of PD activities situated on school premises were explored (Gusky, 1994, 2000, 2003). Although existing models of PD that have frequent sequel meetings have been discussed and compared in the literature, there has not been consensus on a globally accepted definition of sustained professional development (Fraser, 2005). Additionally, many different types of PD models have also been examined in the research literature (Gusky, 1994, 2000, 2003). Included in recent literature was research on school situated professional development models that were implemented in the United States of America, in Israel and in the United Kingdom (Irving, Sanalan & Shirley, 2008; Sanalan, Irving, Pape & Owens, 2008; Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006; Johnson, et al., 2006; Fischer et al, 2004). However, more research is needed on other models of sustained professional development which could help to craft a clearer definition of this type of professional development and assist to delineate the impact of sustained PD on teacher change. This study addressed this need by building upon and adding to recent research on PD models that are situated in the environment where teachers practice, that are sustained for at least one year and that are run by university faculty.

To this end, this study sought to add to the literature by examining the following research questions.

#### Central Question

What can be revealed about the impact of Sustained School Situated Professional Development (SSSPD) by studying teacher learning of Technology Enhanced Formative Assessment (TEFA) in a teacher who emerged as an exemplar?

#### Secondary Questions

- a) How has the participant's practice changed over a period of two years as she integrated TEFA pedagogy into her practice?
- b) Are there predictors that may facilitate change in the practice of this participant? If so, what are the predictors that assist the participant to integrate TEFA into her practice?
- c) How does the SSSPD model affect the participant's practice while implementing the TEFA pedagogy?
- d) How could the findings be used to develop a model of teacher change?

### **C. The Study**

This research studied a teacher learning of new pedagogy while she was participating in Sustained School Situated Professional Development (SSSPD) by examining what was happening in the TEFA project that was utilizing SSSPD. SSSPD was a structured professional development model that was situated on the school campus where the participant taught and that was sustained for three years with a series of regular meetings. The model of SSSPD that was explored in this study was being implemented and coached by faculty from a local university as part of a grant funded

project to provide professional development to facilitate teachers' learning and usage of Technology Enhanced Formative Assessment (TEFA) pedagogy. The two domains of the SSSPD model that was being used for the TEFA project was a professional development (PD) course and collaborative action research (AR) sessions. The SSSPD commenced with an initial 3 day workshop which was followed by weekly professional development sessions for one year and monthly sessions during the second year (Leonard, et al., 2004; Beatty, et al., 2008). Monthly sessions continued during the third year. Although the sessions were sustained for three years, the purview of this study was the first two years of implementation of the SSSPD model. I only studied the first two years of the project because this was within my time frame to complete my dissertation and orally defend it.

The participant in the study was one of a group of ten science teachers and math teachers at a combined middle and high school in Western Massachusetts. The teachers were participating in a Technology Enhanced Formative Assessment (TEFA) project in which they were learning how to use TEFA pedagogy and the immediate feedback of classroom response systems (CRS) to guide and modify their practice. TEFA pedagogy is student-centered, interactive, question-driven instruction that utilizes question cycles to promote dialogical discourse and the use of formative assessment to develop students' understanding (Leonard, et al., 2004; Beatty, et al., 2008).

Formative assessment is the process in which teachers and students use the content of feedback derived from questions, discussion and other sources to analyze the context in which students' assumptions, motivations and self perceptions occur.

Teachers then use the feedback to adapt instruction in response to students' needs during the lesson (Black & William, 1998).

#### **D. Significance of Study**

Teachers are involved in the dynamics of teaching students and preparing them for the future. Teachers operate in various roles to accomplish this overarching goal. The roles of the teachers are enacted through a litany of processes and routines intermingled with and sustained by creative decision making (Shultz, 2005). The nature of the numerous processes, routines and the decisions made by teachers in planning and executing lessons evolve over time as a teacher gains experience. A proficient teacher makes these very complex processes of teaching seem very easy because generally the experienced teacher has internalized the skills (Shultz, 2005).

Like learning any other pedagogy, teacher learning of TEFA is a complex undertaking in which the teacher undergoes a myriad of processes before the new pedagogy could be internalized (Beatty, et al., 2008). Before internalization of new pedagogy could occur, the teacher actually has to change his or her way of being which encapsulates redefining who he or she is as a teacher which then leads to change in actions and beliefs (Feldman, 2002; Feldman, Paugh & Mills, 2004). This study examined the role of the SSSPD model in teacher change. To do this, the intent of this study was to tease out and separate the different processes that lead to teacher change, identify predictors that are precursors to change, identify changes in the participant's practice and explore the impact of SSSPD on changes in the participant's practice.

There were several outcomes of this study. Firstly, this study provided insights about the impact that the SSSPD model had on the practice of a high school science

teacher. Secondly, this research also elucidated the pedagogical methodology and the implementation design of the SSSPD model and their role in influencing change in the participant. Thirdly, this study contributed to the literature on PD models that offer frequent serial meetings on the campus where the teachers practice. Fourthly, the findings of this study generated new knowledge about how a teacher learns new pedagogies which could be used to help teachers effectively integrate new pedagogy into their teaching. Fifthly, the findings from the study were instrumental in identifying predictors and facilitators of teacher change that could be used to assist teachers to successfully integrate TEFA pedagogy in the future. Additionally, findings of this study could also help to inform the university faculty that implement the SSSPD model and assist them to refine the model. Hopefully, the findings could also foster dialogue that could lead to the creation and implementation of more sustained professional development approaches that could improve teachers' practice and thereby improve students' learning in science.

## **E. Specific Considerations**

### **1. Limitations**

A caveat is that this is a case study of one participant and as such the argument may arise that findings from one participant could not form a strong or valid basis for theory formulation. This sample size has its limitations, however while the focus of this study is on one participant this study is embedded in the larger TEFA study that involves nine other participants. Data analysis and findings from the larger study, especially as it relates to case studies compiled of four other participants (Beatty, et al., 2008), were used to inform this study and to provide a better understanding of the

impact of SSSPD on the participant's practice. This study triangulated all findings through the examination of seven distinctive qualitative and quantitative data sources, inclusive of interviews, surveys, classroom observations and archival documents. There was in depth and meticulous analysis of these numerous data sources to identify important phenomena, trace operational linkages over time and reveal patterns that formed the basis of theory formulation.

There were also limitations created by the four secondary questions of this study.

- How has the participant's practice changed over a period of two years as she integrated TEFA pedagogy into her practice?

Change may first occur externally in the participant's actions prior to change occurring in the participant's thinking or change in action may be parallel to change in thinking (Levin & Wadmany, 2007). It may be argued that tracking the evolution of the cognitive process of change in the participant's thinking over a two year period may be difficult. Analysis of baseline data that documented the participant's beliefs and the state of her practice before starting the TEFA project and the comparisons of the findings of the baseline data to other data collected throughout the timeline of this study should counteract any arguments that may arise. Data were used to construct a timeline of tensions that were resolved before changes could take place in the participant's practice. Many quotes were used directly from the data to capture what the participant said about the changes that she made in her beliefs and her practice. The videos of classroom observations were used to triangulate the other data sources as the video taped lessons were examined for evidence of the actuality of the participant's change in the classroom.

- Are there predictors that may facilitate change in the practice of this participant?

If so, what are the predictors that assist the participant to integrate TEFA into her practice?

The limitation of this question was that any predictors that are deemed as being instrumental in the participant changing her practice were identified by the researcher based on critical analysis of the data. These identified factors may exclude others that may have an impact on teacher change that a researcher from a different perspective may identify. The analysis of the other aforementioned case studies (Beatty, et al., 2008) was used to triangulate the findings with regard to predictors of teacher change and the actual change process. The list of factors that influence change and the changes that were revealed by this study is not a complete list as the factors may vary with individual teachers and in other teaching environments. Therefore, caution should be taken with transferring the findings to wider contexts to plot change patterns and identify the mechanisms and process of change in other teachers who are learning new pedagogy.

- How does the SSSPD model affect the participant's practice while implementing the TEFA pedagogy?

This question only looked at the impact that the SSSPD model had on the change in the participant's practice, which precluded other factors that may have had an impact on teacher change. There may have been other factors that influenced the participant learning of the new pedagogy including student reactions and interactions, feedback from parents, administrative and school support and past experiences. Although the exploration of these other contributing factors was not the focus of this study, it was very difficult to decipher the impact that they had on changing the practice

of the teacher. Another limitation was that it is difficult to distinguish and delineate the influence of professional development previously attended by the participant on her learning of TEFA pedagogy and the resultant change in her behavior.

- How could the findings be used to develop a model of teacher change?

A model of teacher learning and teacher change called Elements of Teacher Change in Adoption of Pedagogy (ETCAP) was developed to depict and track change in the participant's practice and to develop a model or framework for the change. The ETCAP model is discussed in Section G of Chapter 4. To develop the model, in depth analysis of data was done to identify important phenomena, trace operational linkages and to reveal patterns (Yin, 2003a, 2003b; Miles & Huberman, 1994; Strauss & Corbin, 1998). The ETCAP model is representative of one participant's progress while she learned and integrated new pedagogy and may not be representative of a larger sample. Thus, the model should be viewed as a work in progress which is just in the foundational stage that has to be validated with further research done with larger samples. Therefore, the concepts of the ETCAP model may only be transferable to some degree in teacher learning and teacher change in similar contexts.

## **F. Theoretical Framework**

Research examining a variety of professional development models and the influence of these professional development programs on assisting teachers to improve their teaching forms the backdrop of this study. Fraser (2005) argued that the existing literature discussed what sustained professional development involves and various frameworks of implementation but did not specifically define continuous or continuing professional development (CPD) (Fraser, 2005). The continuity of CPD are integral

traits of SSSPD. The framework for implementation of PD in recent studies revealed that the main commonalities of the sustained professional development featured in these recent studies were frequent meetings and weekly support that promoted teachers reflection, self-analysis and refining of teachers' practice in a collaborative environment (Irving, Sanalan & Shirley, 2008; Sanalan, Irving, Pape & Owens, 2008; Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006; Johnson, et al., 2006; Fischer et al., 2004). These recent studies added to the literature on sustained professional development that is situated at the schools where teachers practice, but there is paucity in the literature when it comes to studying the effect of SSSPD models facilitated by university faculty on teacher change while learning a new pedagogy.

The process of change that a teacher experiences in adopting and integrating new pedagogy is a multifaceted and multi-tiered process. Teaching is a very complex intellectual, creative decision-making activity rather than a series of routine, habitual, technical acts to be learned, repeated and perfected year after year (Shultz, 2005). Teachers' pedagogical content knowledge is an integral part of the teachers' practice.

Pedagogical content knowledge is a practical way of knowing the subject matter. It is learned mostly on the job from trying things out and observing, talking, and working with other teachers. (Gudmundsdottir, 1995, p.30).

Before new pedagogy could be learned and integrated into teachers' practice, re-organization of the teacher's existing pedagogical content knowledge must occur as they reconcile the relationship of the new pedagogical strategies and their teaching orientation (Gudmundsdottir, 1995). Only an adept teacher could effectively make

practical applications of pedagogical content as he or she goes through the many processes of planning and teaching (Shultz, 2005; Danielson, 1996).

Changing teachers' paradigm and mode of operation is a very complex process (Levin & Wadmany, 2007), therefore it is not easy for teachers to implement new teaching approaches. For integration of new pedagogy and innovations to be successful, they must be supportive of and must positively influence existing beliefs or have a very strong impact on changing the teacher's existing beliefs (Levin & Wadmany, 2007). Therefore, teachers' beliefs are an important consideration by persons planning professional development (Loucks-Horsley 1998; Lumpe & Chambers, 2001). Many professional development activities have been designed to change teachers' model of operations in the classroom and to get them to implement new pedagogy and new approaches (Levin & Wadmany, 2007). However, more research is needed to track the influence of PD on teacher change and the viability of PD models on sustaining teacher change (Leonard, et al., 2004).

Teachers' perspectives about integrating technology into their practice could present a formidable barrier to using technology in the classroom (Angus & Machtmes, 2005; Ertmer, 2005; Wood et al, 2005). Teachers must be skilled in effectively using technology to support students' learning and these must become integral components in every teacher's professional repertoire (Ertmer, 1999, 2005; Earle, 2002; Hokanson & Hooper, 2004; Wood et al, 2005; Angus & Machtmes, 2005) which would facilitate change in what the teacher does in the classroom. It is difficult for teachers to implement changes that require that they change their practices as well as their beliefs, therefore the potential for educational change with new technology and pedagogy are

frequently never realized (Levin & Wadmany, 2007). To address these difficulties and obstacles to teacher change, a professional development model that includes frequent meetings, formative collaboration and technical assistance may provide the necessary components to engender teacher change and support this change over time (Irving, Sanalan & Shirley, 2008; Sanalan, Irving, Pape & Owens, 2008; Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006; Johnson, et al., 2006; Fischer et al, 2004).

## **CHAPTER II**

### **LITERATURE REVIEW OF PROFESSIONAL DEVELOPMENT**

#### **A. Introduction**

The intent of this literature review is to explore five models for professional development of teachers. The models are “one-shot” inservice workshops, Peer Coaching, Communities of Practice, Action Research and Sustained Professional Development. Literature for Technology Enhanced Formative Assessment (TEFA) and literature about integrating technology into teaching is also reviewed. This is followed by a review of literature that gives focus to teachers’ philosophy, beliefs and perspectives as they play a pivotal role in teachers integrating new knowledge and pedagogy learned while participating in professional development. The purpose of this literature review is to point out any gaps in the literature in regard to professional development that is sustained over time and to provide the rationale for research needed to examine a sustained school situated professional development (SSSPD) model. Finally, the TEFA model of Sustained School Situated Professional Development (SSSPD) will be explored in relation to the literature.

A general overview will be given of professional development then the various models of teacher professional development will be explored beginning with “one-shot” inservice workshops. The “one shot” inservice workshop model is being explored because historically it was the most common type of teacher professional development and still remains a popular model that is used to upgrade the skills for teachers. Peer coaching, communities of practice, action research and sustained professional

development are being given focus in this literature review because they are models of school situated professional development that share the commonality of being situated in the professional community in which teachers work and consist of a series of follow-up activities. The four models are not the only models for school situated professional development but they have been chosen because examining the framework of these models and their similarities and differences could help to define SSSPD, illuminate the benefits of the SSSPD model and support the argument for research of SSSPD.

There has been research on school situated professional development activities in which various aspects of the professional development were explored. Although existing models of sustained professional development have been discussed and compared in the literature, this comparison needs to be expanded to include other models of sustained professional development. Sustained professional development is also referred to as continuing professional development or continuous professional development. The research literature has various definitions of sustained professional development that is situated at the school where teachers practice and are sustained over time. The exploration of this literature could facilitate the development of a clearer definition of SSSPD.

Fraser (2005) argued that the existing literature discussed what sustained professional development involves but did not specifically define sustained school-situated professional development (Fraser, 2005). Recent literature has revealed several studies that examined teachers' participation in sustained professional development activities in the United States, Israel and the United Kingdom. Details of the components of each model and framework of implementation of the professional

development were given in each of these recent professional development studies. However, a specific definition of the professional development was not given. The framework for implementation revealed that the main commonalities of the sustained professional development featured in these recent studies were frequent meetings and weekly support that promoted teachers reflection, self-analysis and refining of teachers' practice in a collaborative environment (Irving, Sanalan & Shirley, 2008; Sanalan, Irving, Pape & Owens, 2008; Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006; Johnson, et al., 2006; Fischer et al., 2004). These recent studies added to the literature on sustained professional development that is situated at the schools where teachers practice and that had components that engendered teacher reflection. However, the literature is still limited when it comes to sustained professional development models situated on site at schools that incorporate a professional development course that include action research sessions facilitated by university faculty that are held weekly for the duration of three academic years. Therefore, the information in the literature is incomplete.

Fraser (2005) explored various definitions of continuing professional development (CPD) in existing literature. In amalgamating the definitions from the literature featured in Fraser's article (2005), this researcher broadly defined CPD as professional development that is an ongoing process aimed at effecting change in teachers and change in teachers practice. CPD is further defined as the broadening, development and systematic maintenance of knowledge and skills that allow teachers to develop their own beliefs and ideas about what they need to change in their practice (Fraser, 2005). Fraser (2005) argued that there were many differing definitions of CPD,

many descriptions of the components that constitute CPD and little consensus on what CPD really means. Fraser further opined that the definition and attributes of CPD are not yet fully articulated in existing literature as some researchers “avoid defining the field of their study” about CPD (Fraser, 2005, p. 4).

The lack of an explicit definition of CPD has resulted in disagreements among researchers (Fraser, 2005), which underscores the need for more discussion about CPD. In the literature, CPD has been ill-defined and “implicit, couched within interpretations and descriptions of activities and outcomes” and the implementation of professional development activities (Fraser, 2005, p. 5). Without a clear definition of CPD, comparison of studies and progress towards a more complete understanding of the models of sustained professional development will be impaired. Research is needed to define continuing professional development like SSSPD and to elucidate the components and the effects of SSSPD models. Additional research will also help educators and persons that design and implement continuing professional development for teachers to get a better understanding of the role that SSSPD could play in assisting teachers to acquire and maintain new knowledge and skills which could result in a change in their practice.

## **B. Structure of Literature Review**

The literature review explores research about various aspects of professional development. Section 1 gives an overview of professional development. Section 2 discusses “one shot” workshops. Section 3 examines peer coaching and mentoring. Section 4 describes communities of practice. Section 5 explains action research. Section 6 describes sustained professional development also known as continuing or

continuous professional development (CPD). Technology Enhanced Formative Assessment (TEFA) is described in Section 7. Section 8 explores literature on technology use for education. Section 9 discusses research about teachers' philosophy and perspectives and their impact on teacher change. Section 10 gives insights about the SSSPD model that is being studied.

### **1. Overview of Professional Development**

Professional development is critical for science and education reform and for the improvement of the educational product on the whole (Loucks-Horsley, 1998). The goals of professional development are to assist educators to get a better understanding of research-based instructional strategies and to deepen their content knowledge and thereby help them to improve student achievement (NSDC Standards for Staff Development; Guskey, 2000). Teachers are committed to expanding and maintaining their professional expertise (Fraser, 2005) and want continuing professional development that is high quality, practical, relevant and readily applicable to the subjects they teach (Dillon et al., 2000). Professional development of teachers is an ongoing process that could with continued engagement lead to internalization of knowledge and skills on the part of the teachers (Evans, 2002; Fraser, 2005). Teachers participating in professional development come together to learn with a sense of purpose that will ultimately lead to change in their practice if they can translate what they have gleaned from the professional development to transform what they do in the classroom (Loucks-Horsley, 1998). It is important that professional development is sustained over time to assist teachers to address change as they work towards their own

goals of gaining professional expertise in integrating new pedagogy into their teaching (Killion, 1999).

Teacher development can be viewed as teachers' learning rather than others getting teachers to change. In learning teachers are developing their beliefs and ideas, developing their classroom practice, and attending to their feelings associated with change (Fraser, 2005, p. 5).

For professional development to be successful, "individual learning and organizational changes have to be addressed simultaneously and support one another" (Sparks, 1994, p. 28). The investment of time, energy and resources to transform teachers' instructional methods is well documented. Some of these professional development activities have been effective and many successes have been noted in changing teachers' practice (Guskey, 2003). However, despite this immense investment, achievement of a large percentage of students is still below state and national standards (NSF Science and Engineering Indicators, 2006). The factors which are integral to improving student learning outcomes are content and quality of the professional development program, the organizational culture and climate of the school (Guskey, 2000). A viable and effective professional development program takes into consideration all aspects of training, from preparatory activities, practice and coaching, through follow-up and support activities (Loucks-Horsley, 1998, Guskey, 2003).

## **2. "One-shot" Inservice Workshops**

In the late 1990's professional development in many school districts still consisted mainly of one-shot workshops with little follow-up. "One-shot" workshops are still currently one of the most common types of workshop that are conducted today (Guadelli, 2002). Most teachers only attended these professional development activities for a few hours per year, which is far below the minimum of 60 to 80 hours that some

studies show are needed to bring about meaningful change in teaching behaviors (Guskey, 2000; Supovich & Turner, 2000; NSF Science and Engineering Indicators, 2006). “One-shot” in-service workshops, which are also referred to as one-time or short term workshops are designed to provide training as a one time event with an aim of imparting new knowledge to improve teachers’ ability to support and improve student learning. Short-term workshops are held both in school and out of school with the goal of improving the performance of teachers in developing their professional knowledge, their skills and their attitudes. Most of these “one-shot” in-service workshops are conducted on compulsory training days managed by the district education office and are arranged by the school administration with or without input from teachers (Fraser, 2005).

“One-shot” workshops are usually created in response to specific pedagogical initiatives or to improve subject knowledge that the district deems is necessary. Teachers may leave the inservice workshop with practical tips and maybe with some materials but there is seldom any follow-up (Goldenberg & Gallimore, 1991; Crawford, 2000; Guadelli, 2002; Fraser 2005). After the “one-shot” workshop someone on staff needs to coordinate the collaboration of the teachers so that they could provide support to each other to effectively implement the new pedagogy and get additional support as needed. If no one is there to coordinate collaboration, many of the teachers never implement what they were exposed to at the workshop and if they did, they soon return to their former way of teaching before being exposed to the new knowledge and skills at the “one shot” inservice workshop (Crawford, 2000).

Initiatives were implemented across the United States to address concerns about professional development for educators. In 2001 the Massachusetts Department of education presented its Massachusetts State Plan for Professional Development. The plan was initiated on the premise that effective high quality professional development, strong teachers and visionary instructional leaders are critical for public education reform and improved student achievement. The goal of the Massachusetts PD plan was to expand teachers' knowledge of curriculum, assist teachers to evaluate pedagogical practices and to evaluate the effectiveness of their practice (Massachusetts 2001 State Plan for Professional Development).

Since 2002, 37 states financed professional development programs, 35 states had implemented standards for professional development, and 13 states required districts or schools to set aside teacher time for professional development (NSF Science and Engineering Indicators, 2006). There have been improvements in the types and the levels of professional development activities but the "one-shot" workshop still persist as one of the most common types of professional development activities (Gaudelli, 2002; Fraser, 2005). "Despite the ubiquitous quality" (Gaudelli, 2002, p. 5) of "one-shot" workshops, it does not promote long term change to teachers' practice and have generally failed to transform what teachers do in the classroom (Goldenberg & Gallimore, 1991; Gaudelli, 2002; Fraser, 2005). The lack of efficacy of "one-shot" workshops and their inability to transform teachers' practice indicates a need for professional development that is sustained over time.

**a. Analysis of “One-shot” Inservice Workshops**

There is a direct relationship to the length of and type of professional development in which teachers participate and the increased achievement of students in science and math (Johnson, et al, 2007; Loucks-Horsley et al, 1998). There is a statistically significant relationship between professional development and changes in teachers’ practice when teachers have participated in the professional development experience for at least 80 hours (Supovitz and Turner, 2000).

“One-shot” workshops, some times referred to as “one-time” workshops are professional development that offers brief intervention and are ineffective for promoting long term or lasting change in teachers’ practice. “One-shot” workshops are characterized by information transmission rather than information generation and information exchange (Fraser, 2005). This causes lack of retention or effective use of the information. “One-shot” workshops have not been successful in improving teachers’ ability because there needs to be a greater understanding of how teachers learn to design effective strategies that will equip teachers to improve student learning (Goldenberg & Gallimore, 1991; Gaudelli, 2002; Fraser, 2005).

In many instances there is dissonance between the goals of the “one-shot” workshop and the expectations of the teachers and what the teachers perceive as their needs and the needs of the school. Even when teachers’ expectations are aligned with the goals of the workshop, change in the participants’ practice does not occur and if it does happen it is transient and is not sustained over time (Ertmer, 1999; Ascione, 2006). There is usually no follow-up after the “one-shot” workshop so even if participants felt that it was of benefit, the likelihood of the teachers integrating the skills and knowledge

into their practice and maintaining them over time is very slim (Crawford, 2000). Even when teachers from the same school attend one-time workshops, their continuous collaboration and networking after the event is usually tenuous because of isolation that many teachers experience, because of scheduling, the culture of the school and other factors (Goldenberg & Gallimore, 1991; Crawford, 2000; Guadelli, 2002). These factors make it very difficult for teachers who attended the “one-shot” workshop to build on the skills that were discussed at the workshop, to generate new knowledge or to get practical feedback and support from their colleagues to effectively integrate the new knowledge into their practice.

In summary, lasting change will only occur with continuous and structured immersion in the new pedagogical practice for the teacher to internalize the knowledge and skills and make them an innate part of their practice (Goldenberg & Gallimore, 1991; Crawford, 2000; Evans, 2002; Guadelli, 2002; Fraser 2005). In order for professional development to be effective, it must be sustained with regular and consistent follow-up and supported by modeling, coaching and collective problem-solving in specific areas of practice (Supovitz and Turner, 2000; Loucks-Horsley et al., 2003; Fischer, et al., 2004; Fraser, 2005; Johnson, et al., 2007; Eylan, et al., 2007; Taitelbaum, et al., 2007). One-shot inservice workshops are ineffective because many times they are not aligned with teachers’ expectations, they are mainly designed for knowledge transmission rather than knowledge generation and exchange, the way that teachers learn is not taken into account and there is usually no follow-up support.

### **3. Peer Coaching and Mentoring**

Various alternatives to one-shot workshops emerged in the late 1970’s (Sparks,

1994). Peer coaching was one of these alternatives (Showers, 1984; Showers & Joyce, 1996; Joyce & Showers, 2002). Peer coaching is a professional development method that studies have shown increases collegiality and improves teaching. In peer coaching, teachers share their expertise and provide one another support and assistance which help them to refine their skills, learn new skills, and/or solve problems that they experience in the classroom. Peer coaching is an ongoing process that usually involves an initial training stage that is sometimes followed by various extensions of that training (Showers, 1984).

Peer coaching became popular but did not dislodge the “one-shot” inservice workshop from its position of being the most commonly used method for teacher training in some educational quarters, especially in educational systems of developing countries. Peer coaching and mentoring emerged in the late 1970’s and early 1980’s as a tool to improve instructional techniques (Showers, 1984; Showers & Joyce, 1996; Joyce & Showers, 2002). Most peer coaching models were designed as structured induction programs to assist novice teachers with fewer than three years of experience and although there were peer coaching models for teachers with more experience; they were not prevalent (Bonelli, 1999).

In discussing the history of peer coaching in the article “The Evolution of Peer Coaching”, Showers and Joyce (1996) explained that “teachers who had a coaching relationship – that is, who shared aspects of teaching, planned together, and pooled their experiences – practiced new skills and strategies more frequently and applied them more appropriately than did their counterparts who worked alone to expand their repertoires” (Showers & Joyce, 1996, p. 14). Historically, the role of peer coaching sought to

improve the quality of teaching by increasing the level of collaborative planning, observation, and feedback rather than operating as a formal review or evaluation of how well the new curricula and instructional strategies were being implemented. (Ackland, 1991; Odell, 1990; Perkins, 1998; Showers & Joyce, 1996; Wong & Nicotera, 2003).

Peer coaching was a paradigm shift that resulted in some staff professional development being done as collaborative school-based coaching. The systems of the school that constituted the school culture, the teachers learning in their own context and the results of their learning were integral components of school situated learning through peer coaching (Showers, 1984; Showers & Joyce, 1996; Joyce & Showers, 2002). Sparks (1994) stated that results-driven education, systems thinking and constructivism were altering the shape and the outcomes of teacher professional development.

The literature reflects peer coaching strategies and approaches that are inherent to many different peer coaching models. The numerous models of peer coaching in the literature show differing objectives under one over arching goal which is to improve the teaching process and thereby improve the learning process. These differing goals and expected outcomes seem to suggest that peer coaching may be categorized “into three general categories based on the professional development strategies used” (Wong & Nicotera, 2003. p. 2).

The first category gives focus to technical coaching and team coaching which incorporates new curricula and new instructional strategies into teachers’ practice (Ackland, 1991; Becker, 1996; Showers & Joyce, 1996). The second category centers

on collegial coaching and cognitive coaching which aims to improve teachers' practice by helping teachers to reflect on their teaching, assisting them to identify, modify and refine existing techniques, to develop collegiality and foster professional dialogue (Ackland, 1991; Becker, 1996; Showers & Joyce, 1996). Challenge coaching is the third type of coaching which gives focus to identifying and working to resolve a specific problem that the teacher may be experiencing in the classroom and can potentially be applied to larger contexts like a grade level or even the whole school (Ackland, 1991; Becker, 1996).

Both peer coaching and mentoring strengthen teacher's practice. Coaching is typically a peer relationship with colleagues of similar abilities and experience while mentoring usually involves a more experienced teacher working with a novice teacher to lend support and help him or her improve their practice. The primary activity of peer coaching and mentoring teams is the "collaborative planning and development of curriculum and instruction in pursuit of their shared goals" (Showers & Joyce, 2002, p. 88). When mentoring and coaching are effective, they contribute to an increase in job satisfaction, higher productivity and improvement of skills, enhance teachers' abilities and potential, build mutual commitment and trust, improve skills and performance (Kutilek & Earnest, 2001), strengthens experience-enhancing roles, and encourage collegiality for teachers in the role as coaches and mentors as they engage in co-learning experiences (Killion, 1990). Professional development using peer coaching helps teachers to develop skills for implementing new curricula and strategies while building mutual respect and trust through this interaction while teachers grow together in familiarity with the new strategies (Showers and Joyce, 1996).

In peer coaching, teachers' voluntary engagement helps to develop learning communities that function well and flourish because they are built on and guided by the passions of their members (Snyder & Wenger, 2004). Support is essential for peer coaching to be effective. Becker (1996) and Wong & Nicotera (2003) list the following support components as fundamental to the success of a peer coaching program:

- Trusting relationships with every one involved;
- Support at the administrative level (emotional, organizational, financial);  
sustained learning;
- Clear delineation of expectations (for engagement);
- Assessment strategies for measuring the outcomes of the professional  
development;
- Release time for peer coaching;
- Funding to pay for training and personnel.

Kohler, et al (1997) in examining the effects of peer coaching found that participating teachers modified their practice by making procedural refinements to what they do in the classroom and that many of the changes were maintained and sustained over time.

**a. Analysis of Peer Coaching and Mentoring**

Although peer coaching is school situated professional development that has many benefits and has been successfully implemented at many institutions, there are various reasons why peer coaching has only had minimal success in some institutions or has not been successful in other institutions. Many times for peer coaching to be effective coaches need to be trained in observation skills and pedagogical skills which is

very expensive and time-consuming. Another factor to be considered is that in peer coaching the coach may lack knowledge, experience and/or expertise in areas that need intervention and may not be able to provide the support that is needed by the teacher to modify his or her practice. A coach could discourage a teacher from trying something new if he or she does not support it or the coach could encourage teachers not to change if the coach sees nothing wrong with what they are doing, even though it may be hindering effective instruction (Gusky, 2003).

In peer coaching sometimes personal dynamics of relationships may get in the way of objective critical feedback which is vital for teachers to improve their practice (Hargreaves & Dawe, 1990; Ackland, 1991; Becker, 1996). In some schools peer coaching is structured but in many schools peer coaching is informal and is not structured. Peer coaching that is informal and not structured is not likely to be sustained over time. Another reason why peer coaching may not work is that there may not be a clear delineation of expectations in a coaching relationship. Teachers' schedules and work load could also hinder the success of peer coaching.

One of the biggest drawbacks of peer coaching is that some researchers are against feedback being given (Showers & Joyce, 1996; Joyce & Showers, 2002). There are differing opinions about whether verbal feedback should be a component of peer coaching. Showers and Joyce (1996, 2002) argue that feedback should not be given in peer coaching because it should be supportive and not evaluative (Showers & Joyce, 2002). Further, Showers and Joyce (1996) feel that giving verbal feedback should be used for supervision rather than peer coaching because it weakens teacher collaboration

and suggested that it be eliminated from the peer coaching process (Showers & Joyce, 1996). Joyce and Showers (2002) stated,

We have omitted feedback as a coaching component...Omitting feedback in the coaching process has not depressed implementation or student growth, and the omission has greatly simplified the organization of peer coaching teams in school settings (Joyce & Showers, 2002, pp. 88, 89).

Joyce and Showers (2002) felt that omission of feedback was necessary because coaches often reverted to “supervisory evaluative comments” (p. 89) pointing out what was good and what needed improvement in the lesson. In Joyce and Showers’ (2002) peer coaching model, the teacher that is teaching is redefined as the “*coach*” and the teacher that is observing is referred to as the “*coached*” (p. 89). Joyce and Showers (2002) said that classroom observations were generally followed by brief conversations similar to, “Thanks for letting me watch your work, I picked up some good ideas about...” (p. 89). Showers and Joyce (1996, 2002) strongly recommended that peer coaching should be kept separate and apart from evaluation and supervision.

The controversy over feedback has been over the prohibition of peer review by many unions (Wong & Nicotera, 2003). Showers and Joyce (1996) and any other peer coaching researchers that are against giving feedback have their reasons for this, but the question that arises in this researcher’s mind is how will the teachers know how they are doing and whether they need to change their practice. Teachers need to know whether what they are doing in the classroom works or not. If their methods are working, it is important to know that and for them to realize why their methods are working, how effective they are and then share successful strategies with colleagues which could help them to improve their practice. If their methods are not working, they need to know so

that they could work towards improving them. Teachers also need to know if their perception of what works and what do not work are consistent with other stakeholders' perceptions. As an educator who has worked with many teachers for over 20 years, it is felt that collaborative and positively critical feedback in voluntary peer coaching is vital for improving teachers' practice.

When thinking about peer coaching, the main consideration is whether the teachers are understanding more deeply the content they teach and whether the peer coaching model assists them to effectively implement curricula and integrate new pedagogy into their practice. School situated professional development activities like peer coaching should promote collegiality and collaboration (Showers and Joyce 1996, 2002). However, without clear direction and purpose, individuals can collaborate to resist reform and prevent improvement efforts and could impede teachers' improvement of their practice rather than enhancing their practice (Guskey, 2003).

#### **4. Communities of Practice**

In communities of practice, theories, ideas and ways of understanding are developed, negotiated and shared in a community of members who are reflective on the nature of their own practice (Wenger, 1999). Communities of practice consist of persons who share a common concern or passion that come together in group interactions in which collective knowledge is constructed largely through informal narrative discourse by its members (Wenger, McDermott, & Snyder, 2002). The merits of communities of practice have long been heralded in the domain of business, however the application of communities of practice in education is expanding (Linehan, et al, 2005). There are many uses and purposes of communities of practice. Members of

communities of practice have direct engagement in specific activities with specific purposes and derive meaning of shared experience in the context of their working environment.

Communities of practice are a means for professionals to share informal or tacit knowledge from their experience and for them to share critical information that is only acquired from day-to-day experience (Linehan, et al, 2005). Communities of practice promote collaborative problem solving in an environment that fosters accountability to the professional standards of that community of practice (Wenger, 1999; Saint-Onge & Wallace, 2003; Linehan, et al, 2005). In the school setting, there is continuous collaboration, problem solving and sharing of day to day experiences between educators. This collaboration is done in informal settings like casual discussions in the lunch room or staff room and more formal settings like meetings and seminars.

The actual accomplishments of instructional change that can be sustained and extended over time is most likely to occur in professional development programs with continuous collaboration (Kohler, et al, 1997) and are much more effective than just a one time professional development event (Becker, 1996; Wong & Nicotera, 2003). The continuous collaboration of communities of practice in school settings lends itself to ongoing professional development that helps educators to evaluate and improve in the context of their practice. Communities of practice support teachers learning through continuous collaboration. Practice and identity are key components of communities of practice (Wenger, 1999). The foundational concept is that people learn best from ongoing interaction when they are mutually engaged (learning and doing together) with their peers which results in a deepening of their knowledge and expertise. Through

mutual engagement the members develop a “shared repertoire of resources: experiences, stories, tools, ways of addressing recurring problems – in short a shared practice” (Wenger, 2001, pp.2-3). “The extent to which practice and identity are invested in mutual engagement determines the cohesiveness of the community” (Wenger, 1999, p.86). The minimum amount of time needed to affect change in teachers’ practice is not as important as sustaining mutual engagement of members (Wenger, 1999).

Communities of practice have three basic dimensions: domain, community and practice which impact the effectiveness and strength of the communities (Snyder & Wenger, 2004). Schools are situational venues of communities of practice where teachers can learn from each other as they bring their collective experience and expertise to enrich each other and improve their teaching (Lave & Wenger, 1991; Wenger, 1999). Collegiality and collaboration underpin effective communities of practice and these communities flourish when they are based on voluntary engagement (Snyder & Wenger, 2004) and are strengthened by the quality of the relationships that bind the members together (Killion, 1990; Conner & Clawson, 2004). Although communities of practice are not new, more and more organizations are realizing their benefits and are cultivating these learning communities. There is knowledge in organizations that is aligned with and dependent on a person’s professional identity. It is difficult if not impossible to codify how the knowledge is aligned with a person’s identity. These communities of practice include a variety of collaboration methods and models that enhance teachers’ pedagogical skills and competencies and promote continuous improvement and practice while encouraging teachers to be proactive in improving their teaching (National Staff Development Council (NSDC), 2001).

Hallmarks of communities of practice are informal learning activities and personal relationships among colleagues (Snyder & Wenger, 2004). In communities of practice informal learning plays a much bigger role than formal learning in disseminating knowledge. Informal learning tools like stories, conversation, and lessons learned from experiences help the participants find a common ground with which they could identify. The informal learning tools also give members of the community opportunities to take from the shared experiences whatever they need to expand their repertoire of strategies that will enable them to more effectively implement the new curricula or technology (Snyder & Wenger, 2004).

Teachers have been involved in communities of practice that served various purposes. They are continuously involved in daily professional conversations that are the hallmark of communities of practice. Additionally, they may also be involved in regularly scheduled meetings. Faculty may meet monthly to assess its progress, school teams may meet regularly to focus on goals for school wide improvement, learning teams may meet regularly to discuss practical ways of improving teaching and learning. Administrative communities of practice meet regularly to share ideas, learn important skills, get a better understanding of educational leadership and to support one another. There are also virtual networks of online communities of practice where persons assist each other to learn new things and offer feedback and support (National Staff Development Council, Standards for Learning Communities). The positive effects of peer coaching that are intrinsic to communities of practice are heralded in literature.

**a. Analysis of Communities of Practice**

There are many advantages of communities of practice. There are also several limitations. In communities of practice, members have to “sustain enough mutual engagement (learning and doing together) in pursuing an enterprise together to share some significant learning” Wenger, 1999, p. 86). The biggest drawback of communities of practice is that mutual engagement is considered more important than the minimum time needed to affect change in teachers’ practice, and knowledge is constructed through informal narrative discourse (Wenger, 1999). The emphasis in communities of practice is on sharing anecdotes any time the teachers are together when in the staff room, having conversations in the corridors or during faculty meetings rather than on structured sessions to address a specific pedagogical or curricular needs. The amount of sessions that constitute minimum time is not defined so there are no guarantees that the process of change would occur (Wenger, McDermott & Snyder, 2002). Communities of practice are difficult and time-consuming to establish and maintain. Once established, communities of practice need to be well supported or they collapse (Wenger, McDermott & Snyder, 2002).

The continuous flow of knowledge among members through mutual engagement would be good if the repertoire reflects increased knowledge and current research-based pedagogy that could improve teachers’ practice. As in the case of peer coaching, in a community of practice you can design an environment that could either facilitate or frustrate emergent practices and identity (Wenger, 1999). Internal relations, perspectives and ways of teaching could be so firmly embedded that they are resistant to the shared enterprise and mutual engagement of the community of practice. Communities of

practice can easily develop flaws because teachers just propagate the same pool of knowledge which is continuously circulating.

Communities of practice can add to the complexities of an institution because of its heavy dependency on a community of shared enterprise. More vocal members of the community of practice, those who are more assertive or of those who may be jostling for position or special recognition could be problematic for the effectiveness of communities of practice (Wenger, 1999) . This could also result in difficulties being experienced in managing the learning community. Wenger (1999) acknowledged that you cannot design the learning in a community of practice, however you could design the community for learning. By sharing knowledge through informal discourse it is hard to measure whether learning is occurring, the amount of learning taking place, the quality of learning, and whether learning will lead to a change in practice.

## **5. Action Research**

Action research is “systematic inquiry by practitioners to improve teaching and learning” (Feldman & Capabianco, 2000. p. 2. Fleming (2000) defined action research as “a systematic inquiry into a school or classroom situation with the intent of inspiring the quality of teaching and learning and gaining a deeper understanding of the complex context in which it occurs” (p. 11). Teachers engaged in action research are in the role of researchers for the purpose of studying their practice, exploring processes of learning or participating in curriculum development and research (Feldman & Capabianco, 2000; Feldman & Minstrell, 2000; Feldman, 2002). Action research has the potential to overcome barriers to change through strategic and prescriptive action (Somekh, 2006).

Action research is another model of school situated professional development. “School employees will also learn through such diverse means as action small-group problem-solving, observing peers, journal writing, and through involvement in improvement processes” (Sparks, 1994) which are key components of action research. One goal of action research is for education practitioners to process their practice so that they can have an improved understanding of the educational situations in which they teach. Secondly, another goal of action research is to improve teachers’ practice. By reflecting on and analyzing their practice, the teachers become part of the knowledge base of teaching and learning (Feldman & Minstrell, 2000). Action research has a twofold purpose. The first purpose is to inform and improve teachers’ practice by changing or modifying what teachers do in the classroom and in so doing improve teaching to improve student learning. Secondly, action research seeks to examine a teacher’s actions to gain insight about what is working in a classroom and what is not working (Altrichter, et al., 2002; Feldman & Minstrell, 2000; Feldman, 2002; Feldman & Capabianco, 2007).

Action research groups are groups of practitioners that meet regularly to reflect on their practice. Action research groups offer a supportive framework in which teachers benefit from peer coaching and symbiotic exchange and enrichment of knowledge and skills. One of the domains of science education in which action research has been utilized is teacher education and professional development (Feldman & Capobianco, 2000, p. 4).

Action research highlights teachers as reflective practitioners engaging in inquiry into their teaching practice while being self-directed learners (Altrichter, Posch &

Somekh, 1993; Feldman & Capobianco, 2000; Feldman, Paugh & Mills, 2004). Self reflection is critical for teachers to gain insights about their practice to enable them to improve schooling (Feldman, 2003). Teachers' beliefs and practices and their formulation of theory develop through their actions. Teachers are interested in whether their actions in the classroom are positively affecting student learning. By reflecting on their actions through action research, teachers break down their actions into small steps and processes that could help them to articulate what they do as teachers. Teachers operate in the role of researchers studying their own methods of practice as they engage in self reflection and analysis through action research (Feldman & Capabianco, 2000; Feldman, 2002; Feldman & Capabianco, 2007).

The benefits of teachers in the dual role as classroom teachers and researchers as they participate in collaborative systematic inquiry are documented in action research literature (Feldman & Minstrell, 2000; Altrichter, et al., 2002). The products of action research are the growth of teacher's knowledge about teaching and learning, increased understanding of practice, improvement in teaching and learning and teachers' empowerment as professionals who realize their ability to test their ideas by using systematic inquiry to better understand the educational situation in which they practice (Feldman & Minstrell, 2000; Feldman, 2002; Feldman & Capabianco, 2000). This results in teachers having a heightened awareness of how to change their practice. Teachers have a sense of personal fulfillment as they engage in collaborative action research to analyze their teaching practice, to solve problems and validate their practice as action research provides a forum for authenticity and validation of a person's practice (McCutcheon & Jung, 1990).

Action researchers test ideas by putting them into practice then they evaluate their ideas and either adapt them or develop new ones and then use the ideas to modify or to change their practice (Feldman & Capabianco, 2000; Feldman, 2002; Feldman & Capabianco, 2007). McCutcheon and Jung (1990) discussed six steps of action research recommended by Taba and Noel (1957): (a) identifying problems, (b) analyzing problems and determining cause and effect relationships, (c) formulating tentative ideas about causal factors, (d) gathering and interpreting data to sharpen these ideas and developing action hypotheses, (e) formulating action, and (f) evaluating the results of the action. This process of action research is summed up as the “spiral of action research cycle” with first the planning, next putting into action what was planned, then teachers observing and reflecting on their practice followed by revising the plan as teachers continue to reflect on their practice (Altrichter, et al., 2002, p. 130). Teachers in depth reflection and analysis of their practice are prerequisites for them changing their practice. Teachers changing their practice could have positive impact on changing the structure of the school in which they practice. The main goal of action research could also be to change the structure of the organization instead of changing teachers’ practice.

Action research can change the social system in schools and other education organizations so that continual formal learning is both expected and supported. It can replace superficial coverage with depth of knowledge and it can generate data to measure the effects of various programs and methods on students and staff learning (Calhoun, 2002, p. 18).

As teachers reflect on and analyze their practice, they develop increasingly complex levels of reflection (Ornstein, 1995). Teachers analyzing their practice helps teachers be to critical of their roles and define, redefine and refine what they do as

teachers as precursor to them changing their practice (Feldman, Paugh & Mills, 2004). Before teachers could define, redefine and refine their practice they have to define, redefine and refine their existential perspective. In discussing the existential perspective Feldman (2002) explains that this concept is not a characteristic of the teacher as much as it is the characteristics of teachers' knowledge and reasoning skills. Feldman's research suggests "that teachers' actions, intentions, and beliefs are manifestations of their ways of being teachers" (Feldman, 2002, p. 233).

Teachers are products of the situations in which they find themselves and what they choose to do in those situations. Our perception of self, what we value and what is important to us is dictated by our personal identity. Our identities are constantly shaped, transformed and redefined by our practice (Feldman, 2002). Teachers' identities as teachers are carved by these experiences and are affected by relationships and interactions with different persons and the influences of the environment. The person's self concept as a teacher is defined and informed by the teacher's past experiences and the teacher's self concept is situated in the current experiences of the teacher and the teacher's beliefs and intentions of what could be. Teachers' reflection of self and of their "way of being" could assist "teachers to gain an authentic image of themselves as practitioners. Teachers could change only by changing their way of being teachers" (Feldman (2002, p. 234).

How do teachers change their way of being teachers? This is a very complex and difficult process for all teachers, especially for teachers who have constructed their professional identities and their perception of self over many years of practice. This process of redefining who they are as teachers means that the teachers have to examine

their beliefs and dissect entrenched practices which could cause tension. This self examination could produce friction between the safety and comfort of holding onto what the teacher has worked hard to become or to achieve and the uncertainty of what he or she might become or achieve and whether the students will benefit. The level and depth of reflection are based on a person's maturity, confidence and the perceived safety in expressing his or her views (Ornstein, 1995).

There are instances in research literature where action research has been used as a tool for professional development. Somekh (2006) discussed the use of action research by 100 teachers in 24 schools to explore the impact of using a computer on students' learning in the Pupil Autonomy in Learning with Microcomputers (PALM Project). PALM was a collaborative project between a university-based research team and the participating teachers. One goal of the PALM project was to test "the hypothesis that professional development of ICT (*Information Communication Technologies*) would result naturally from involvement in research into learning while using ICT" (Somekh, 2006, p. 92). Another study was a descriptive and explorative case study that examined professional development in which action research and facilitation by university faculty were used to explore the development of professional knowledge by teachers over the course of two years (Ponte, et al, 2004).

**a. Analysis of Action Research**

Some concern has been raised about the credibility of teachers researching their own practice, the inherent biases of the teachers, the difficulty in measuring changes in the teachers and students and the greater difficulty in isolating factors that contribute to any changes that may occur (Feldman & Minstrell, 2000; Feldman 2007). While these

are valid points that should be addressed, it should be noted that action research rigorously supports the need for trustworthiness and credibility through various means. Feldman (2007) argued that validity and quality are important to action research and that there are things that action researchers need to pay attention to which demonstrate validity in qualitative studies. Action researchers need to “pay attention to how they inquire into their practice, and ways to assess how well that has been done” (Feldman, 2007). Additionally, action researchers need to provide clear and detailed descriptions of data collection, provide clear detailed descriptions of how their narratives were constructed from the data, triangulate the findings with multiple sources of data, use a variety of ways to represent the same data and provide evidence of the value of action research in changing the way that teachers teach (Feldman, 2007).

Another consideration is the conflicts that may arise from the structure of funded projects for action research and the incongruence of what the teachers consider practical for them and the expectations of the person or persons’ organizing the action research. The assumptions that teachers have about action research and the power dynamics with regard to the facilitation and the structure of the action research could also cause tension. (Feldman & Minstrell, 2000). Tensions with power dynamics, structure and expectations of action research could be diffused with dialogue and adapting the model to suit the needs of the participants when necessary. The concerns are minimal when compared to the benefits that educators will derive from self reflection and self analysis of their practice through action research and the positive changes that could result.

This review of literature of professional development sought to elucidate the frameworks, characteristics and components of four PD models. The PD models

featured in this literature review are “one shot” workshops, peer coaching and mentoring, communities of practice and action research. The discussion of the four PD models revealed that there were commonalities between all four models and also some distinct differences. The four models discussed in this literature review have all had varying degrees of success with the “one-shot” workshop emerging as the least effective and the least likely to effect change in participants’ practice according to research literature.

An analysis was done of each model. The analysis illuminated some of the drawbacks of each PD model. The inherent drawbacks of the four PD models under review underscored the need for professional development models that are designed to have structured frequent sessions and that are situated onsite where teachers practice.

## **6. Sustainable Professional Development**

For the remainder of this literature review, sustainable professional development (SPD) will be discussed which will be followed by Technology Enhanced Formative Assessment (TEFA) in section 7 and technology in section 8. In section 9 the Sustained School Situated Professional Development (SSSPD) model that was studied will be described and arguments made as to: 1) how SSSPD could impact teacher learning of new skills, 2) why SSSPD could be a viable and effective model for integrating technology into teaching, and 3) why additional research about SSSPD is needed to inform existing literature.

Sustainable professional development (SPD) includes continuous professional development (CPD) also referred to as continuing professional development.

Sustainable professional development is grounded in “situative” (Lave & Wenger, 1991,

p. 29) theories of knowledge and learning and is situated on the school campus. One of the main goals of sustainable professional development is to assist teachers to deepen their content and pedagogical knowledge while providing opportunities for them to reflect on their teaching in a formative collaborative environment (Goldenberg & Gallimore, 1991; Gaudelli, 2002; Gusky, 1994, 2000, 2003; Feldman & Minstrell, 2000; Feldman & Capobianco, 2000, 2007). Another goal of sustainable professional development is to provide consistent support and assistance for teachers in the form of meetings or other collaborative opportunities scheduled at least once a month. These characteristics of sustainable professional development facilitate teachers' integration of the new pedagogy into their practice (Fischer, et al., 2004; Johnson, et al., 2007; Eylan, et al., 2007, Taitelbaum, et al., 2007).

Sustainable professional development is structured professional development that is sustained for at least one year but sometimes up to three years. The structure of various sustainable professional development models supports the need espoused in the literature for professional development to have frequent and long term support and follow-up (Supovich & Turner, 2000; Gusky, 2000; Evan 2002; Fraser, 2005; Killion 1999, Johnson, et al., 2007). Some sustainable professional development models consist of a summer institute or some initial induction activity that gives an overview of the professional development. This initial activity is then followed by a series of regular structured meetings where teachers collaborate on their practice and are held at least once a month for the duration of professional development. There are various opportunities for collaboration in between meetings (Fischer et al., 2004; Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006).

Professional development that consists of frequent meetings conducted over the course of one year or more facilitate the transformation of teachers' practice over time because it supports the construction of knowledge and integration of new pedagogy (Guadelli, 2002; Fischer et al., 2004; Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006; Johnson, et al., 2007; Leonard, et al., 2004; Beatty, et al, 2008). The longevity of professional development also affects the reinforcing, reshaping and redefining of teachers' practice (Kohler, et al, 1997; Supovich & Turner, 2000; Guadelli, 2002; Johnson, et al, 2007). Other components of sustainable professional development may include classroom observations, interviews, online support, online community building and collaboration, collection and analysis of artifacts, surveys and follow-up workshops (Guadelli, 2002; Fischer et al, 2004; Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Johnson, et al, 2007).

Sustainable professional development could be multi-faceted and designed for research of teacher learning and change as well as for teacher professional development (Leonard, et al., 2004; Beatty, et al, 2008). Sustainable professional development allows teachers to identify and examine the complexities of teaching in a collaborative environment and engenders change in the teachers' thinking and practice while they learn a new pedagogy (Leonard, et al., 2004; Beatty, et al, 2008; Eylon, Berger & Bagno, 2007; Taitelbaum, et al, 2007; Gatsby Technical Education Projects, 2006; Johnson, et al, 2007). The research component of some sustainable professional development models could give researchers and designers of the professional development insights about how individual teachers learn (Leonard, et al., 2004; Beatty, et al, 2008) and how changes in teachers practice impact the organizational structure of

the schools (Sparks, 1994; Loucks-Horsley et al., 1998; Supovich & Turner, 2000).

Some sustainable professional development may be facilitated by university faculty, others may be facilitated by teachers or other educators, or jointly by university faculty and other educators.

It is imperative for effective professional development to be designed to enable teachers to successfully integrate new pedagogy into their classrooms (Loucks-Horsley et al., 1998; Supovich & Turner, 2000; Johnson et al, 2007; Leonard, et al., 2004; Beatty, et al, 2008; Sanalan, Irving, Pape & Owens, 2008). The main goal of sustainable professional development is to assist teachers to incorporate new knowledge and pedagogy into their practice and to facilitate the teachers' reflection and analysis of their practice so that they could define and refine what they do as teachers. Sustainable professional development affords teachers the opportunity to examine and redefine beliefs and structures that are imbedded in their practice in a formative environment (Leonard, et al., 2004; Beatty, et al, 2008; Eylon, Berger & Bagno, 2007; Taitelbaum, et al, 2007; Johnson, et al, 2007). Collaborative discourse is one of the pillars of sustainable professional development. Collaborative discourse in sustainable professional development helps to reveal teachers' tacit and hidden knowledge, clarifies teachers' understanding, helps teachers construct new knowledge, and reinforces their pedagogical identity (Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006).

The opportunity for teachers to reflect on their work is an important aspect of any effective professional development program. The teachers' ability to reflect on their practice is enhanced by discussing teaching and learning with their colleagues

(Taitelbaum, et al., 2007; Altrichter, et al, 2002; Feldman & Minstrell, 2000; Feldman, 2002; Feldman & Capabianco, 2007). Teachers use data that they have collected from their classes to help them reflect on their practice. Sustainable professional development creates a professional learning community situated in the place of the teachers' practice that supports the sustainability of the professional development far beyond the teachers' actual attendance at the weekly professional development course (Evans, 2002; Fraser, 2005; Fischer et al., 2004; Johnson et al., 2007).

In exploring the phenomenological perspectives of participants who participated in professional development, Guadelli (2002) stated that a meaningful alternative to the one-shot workshop is professional development held for extended periods that incorporate existing scholarship of teachers and included opportunities for thoughtful reflection upon their experiences, past as well as present. When these factors are taken into account, "teachers derive individualized meanings and renewed direction for their professional work" (Gaudelli, 2002, p. 1) and have a greater awareness of who they are and what they do as teachers. McChesney (1998) argued that effective professional development organizes teachers into learning communities that are seeking continuous and sustained instructional improvement. Change must be established at the school level in order to realize significant improvements in student achievement (McChesney, 1998). Following are some examples of CPD models that have been discussed in recent literature.

#### Study 1

Fischer et al, (2004), a team of university faculty who referred to themselves as cluster consultants conducted professional development in schools once a week for three

years. The goal of this project was to assist high school teachers to better prepare students who were at risk for not being able to meet the entry requirements for college. The faculty consultants utilized a professional development model that they created called Deeply Embedded Professional Development (DEPD) as an alternative to “replacing one-shot, one-way programs with long-term collegial work” (Fischer et al, 2004, p. 204).

### Study 2

The Discover Inquiry Test (DIT) study was research done to assess the effect of a sustained whole-school professional development program on student achievement in which the entire science department of a middle school participated. Results of the DIT study showed that science students of teachers who had participated in the sustained professional development scored significantly higher on the Discover Inquiry Test (DIT) than students of teachers in a comparable school who did not participate in the sustained professional development. These findings showed that there was a relationship between student achievement in science and teacher participation in sustained collaborative professional development (Johnson, et al., 2007).

### Study 3

This is a study of 21 science teachers from 10 different states who participated in CPD that was a professional development program for classroom connectivity technology implementation in the teaching of physical science. This sustainable professional development was two years in duration. The sustainable professional development was comprised of: 1) a week-long summer institute, facilitated by high school science teachers who were successfully using the technology in their classes, 2)

online support that included help with trouble shooting, 3) online community building through discussion forums, and 4) two follow-up workshops which were conducted by university faculty at annual conferences for teachers teaching with technology that the participants of the study attended.

The implementation of the classroom connectivity technology project was carefully monitored by the university research team who also conducted classroom observations and telephone interviews as well as provide on-going support. Peer collaboration was provided on site and also online. Although the teachers initially experienced some challenges with getting appropriate resources, they reported positive change in their practice in the areas of their planning, their delivery of instruction and their formative assessment practices. These findings suggest that this sustainable professional development model had a positive impact on the teachers' implementation of new technology and on the changes that they made to their practice (Sanalan, Irving, Pape & Owens, 2008).

#### Study 4

This study is comprised of case studies of three physical science teachers' implementation of connected classroom technology. The three participants were from significantly different teaching contexts and had completed their first year in the multi-year connected classroom project. The teachers were using a system of hand-held classroom devices for technology facilitated formative assessment. The Navigator<sup>TM</sup> was the technology used for this study. This study was a pilot study of the larger project called Algebra 1 Classroom Connectivity in Promoting Mathematics and Science Achievement (CCMS). The goal of CCMS was to investigate the impact of connected

classroom technology with interactive pedagogy and professional development on mathematics and science achievement, student self regulated learning, students' dispositions toward mathematics and science, and teacher professional growth. This sustainable professional development model consisted of provision of technology, a one week summer institute, online web training and discussion forum and professional development at an annual conference. Initially, challenges were experienced by the teachers in making the changes necessary to existing classroom structures and procedures to integrate the new technology. The teachers believed that the technology was compatible with traditional assessment, formative assessment and hands-on data-collection lessons. The benefits derived from the sustainable professional development for the participating teachers included better awareness of students' learning, increase of students' engagement in on-task behavior and students being better informed of their own learning (Irving, Sanalan & Shirley, 2008).

#### Study 5

The changes in the practice of fourteen chemistry high school teachers in Israel were examined as they participated in CPD that taught them to use the inquiry approach in the chemistry classroom laboratory. The CPD also supported the teachers' integration of the inquiry approach into their teaching. The CPD model consisted of three phases; the development of the teacher's guide, the summer course and the workshop meetings that were held once a month for two years. The teachers participated in online discussion forums between meetings. Teachers' lessons were video-taped and they were interviewed immediately after the lessons. The results reflected that there was change in the participants' pedagogical and content knowledge and that the teachers

became more aware and reflective of their practice as a result of participating in the CPD. The findings suggest that CPD facilitated the teachers being able to analyze and understand their teaching by being more reflective in scrutinizing and criticizing their own work (Taitelbaum, et al., 2007).

#### Study 6

This is a study of 12 high school physics teachers in Israel who participated in an evidence-based continuing professional development (CPD) program that gave focus to knowledge integration (KI) pedagogy. The participants met once a month for a year at the school where the teachers practiced and participated in online interactions between meetings. The teachers learned various knowledge integration routines (KIR) which they integrated into their classes. During the study, the teachers' reflected on their integration of KIR during their collective discourse in meetings. The collective discourse enabled the participants to explore each other's teaching strategies, their perceptions of students' learning and provided a collaborative forum for teachers to problem solve and share ideas about improving student learning. The participants' discourse was analyzed and used as an investigative tool to provide evidence of teacher learning and use of KI throughout the program. The teachers in the study acknowledged that self examination of their practice in a continuous collaborative environment resulted in significant changes in their knowledge about their students and in their perceptions about KI pedagogy. These changes in their knowledge and perceptions were instrumental in them changing their practice and in improving the learning of their students (Eylon, Berger & Bagno, 2007).

#### Study 7

Studies five and six were part of study seven which was CPD on a larger scale that was a collaboration between King's College, London and Weizmann Institute, Israel. The main goals of the CPD was to facilitate evolution of the teachers' practice by assisting teachers to recognize what they do in the classroom, and assisting them to refine and improve their teaching practice in a collaborative environment. The teachers in both countries worked on 1 of three domains of science which were: 1) science argument, 2) science learning, 3) assessment for learning, 4) learning skills for science, 5) inquiry in the chemistry lab, and 6) knowledge integration in learning physics. Teachers in the United Kingdom concentrated on the first three science domains while teachers in Israel gave focus to the last three domains.

The teachers met in regular meetings held over the course of 6-12 months. The meetings were between 3-5 hours in length with the amount of time for group meetings totaling between 20-30 hours. Teachers tried out new ideas between meetings and collected evidence of changes in their practice to share at the next meeting. During the meetings the teachers' reflected on classroom outcomes and their formulation of questions. The teachers' descriptions of teaching and learning prompted professional dialogue, reflection and critiques that resulted in enhancement of their practice. Collection, analysis and reflection on evidence from the classroom were used as a basis for teachers to transform their practice. Evidence of the teachers' change in their practice was compiled in portfolios that consisted of class work, homework, assignments, test scripts, lesson plans, interview transcripts of participants and evaluation of sessions by participants. The results revealed that the collaborative and formative environment and the frequent meetings of the CPD, helped teachers to adopt

and adapt ideas from their colleagues which they tried in their classrooms then reflected of how they worked in their individual contexts. The teachers used their reflection to analyze their teaching and then evaluate themselves (Gatsby Technical Education Projects, 2006).

Sustainable professional development has two important aspects, attitudinal and functional. Attitudinal denotes intellectual and motivational changes that may occur during the professional development. The functional aspect denotes procedural and productive change (Fraser, 2005; Evans, 2002). The goal of sustained professional development should not be to give information with a view of getting teachers to change their practice but rather it is to encourage self-reflection, thoughtful analysis and understanding of ones' practice (Dewey, 1924; Feldman & Minstrell, 2000; Feldman, 2002; Feldman 2007) as a vehicle for teachers to develop increased proficiency in their practice which will result in change.

It is important to understand teachers' perspectives on what they consider effective professional development as they work collaboratively to understand their practice, strengthen their professional performance and to be self directed learners (Costa & Garmston, 2002) as they learn to implement a pedagogy. One of the most frequently mentioned characteristics of effective professional development is enhancement of teachers' content and pedagogic knowledge and its role in helping teachers get more in depth understanding of the content they teach and the ways that students learn (Guskey, 1994, 2000, 2003).

The belief that under girds all of the sustainable professional development models mentioned in the literature is that the most powerful way of achieving long term

change in teachers' practice is for professional development to occur in school situated collaborative teams. These collaborative teams should meet frequently for the purposes of sharing, learning, and problem solving in response to needs they have identified (Fischer, et al., 2004; Johnson, et al., 2007; Eylan, et al., 2007, Taitelbaum, et al., 2007). When there is an expressed need for their existence, continuous sustained professional development is most dynamic and effective (Guadelli, 2002).

Sustainable professional development formalizes and structures teachers' interactions while the value and contribution of each participant is the supporting structure on which the expansion of knowledge, the identification of the way of knowing and the way of doing is embedded. In the sustainable professional development model, the teachers use what they have crafted during their years of practice as the scaffold to learning to integrate new skills into their teaching as they build upon and remodel their way of doing while expanding their professional expertise. Sustained professional development assists teachers to effectively integrate new pedagogy into their curriculum, facilitates change in the teachers' practice and contributes to the sustainability of those changes over time. Technology Enhanced Formative Assessment (TEFA) pedagogy is one such pedagogy that teachers could integrate into their teaching which has the potential of transforming the way teachers teach science and the way that students learn science.

**a. Analysis of Sustainable Professional Development**

The seven studies that were featured in this sustained professional development section all had findings that suggested that the participants benefited from the SPD in various ways. The results of the studies reflected that change had occurred in the

participants' pedagogical and content knowledge which was credited to the professional development being sustained over time. The commonalities of the seven SPD models included being sustained over time, having regular structured interaction between participants and opportunities for teachers to reflect on and analyze their practice. The SPD's had different structures and frameworks of implementation. The duration of the SPD's ranged from 6 months to three years. Some of them had regular meetings on site in the professional communities where the teachers practiced while others relied on online support and online discussions because participants were in different locations. The first study had face-to-face weekly meetings while others had face-to-face meetings once a month. Two of the online studies had weekly interaction between participants. A few of the studies were facilitated solely by university faculty while others were facilitated jointly by university faculty and teachers. There were also differences in the foci of the seven studies. Some of them gave focus to changes in students achievement as the main goal whereas others gave more focus on teachers changing their pedagogical and content knowledge. There are some commonalities between the SPD models in the seven studies and there are also some inconsistencies which supports Fraser's (2005) argument that there needs to be a clearer definition of continuous or continuing professional development. The inconsistencies in these seven SPD models underscore gaps in the CPD literature when it comes to sustained professional development. The inconsistencies also make a poignant point for additional research about sustained school situated professional development that is implemented on site where participants practice, that is facilitated by university faculty and that consists of a PD course and action research.

It is imperative to improve the quality of teachers' practice and thereby improve student learning. One of the best ways to improve teachers' practice is to provide effective, accessible professional development that addresses the situated needs of teachers and that are sustainable over time. Professional development with serial follow-up that takes place in the teachers' professional community is an effective method of addressing teachers' needs as they learn to integrate new skills into their teaching. The provision of regularly scheduled structured assistance and support that facilitates retention and maintenance of teachers' new skills over time is one of the strengths of sustainable professional development (Fischer et al., 2004; Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006). Sustainable Professional Development is characterized by formal structured sessions that are held at least once a month for at least one year. Collegiality and collaboration with defined goals and a common purpose are promoted by sustainable professional development (Fischer et al., 2004; Eylon, Berger & Bagno, 2007).

A caveat for any model of continuous professional development is that there must be clear expectations of the facilitators and the participants. If expectations are unclear, there will be a lack of understanding of what the sustainable professional development entails which could significantly affect the teachers' perception of the relevance and the quality of the professional development. Additionally, sustainable professional development may be difficult to implement because its success is dependent on the availability and accessibility of resources and of facilitators who may have very demanding schedules. Weekly or even monthly scheduling of sessions may also pose a problem for teachers with all the demands on their time. Funding for

continuous professional development could be a factor that could impede the sustainability of implementing this professional development for at least one year.

There are some characteristics that sustainable professional development have in common with peer coaching and mentoring and with communities of practice including information exchange and problem solving through collaboration, mutual engagement and shared practice. However, sustainable professional development has some distinct differences that distinguish it as a different model of school-based professional development than peer coaching and mentoring and communities of practice. How is sustainable professional development different from peer coaching and communities of practice? Table 1 on the next page shows the main traits of peer coaching and mentoring, communities of practice and sustainable professional development and gives a glimpse of their differences.

Some main differences between the three models are that sustained professional development has : 1) regularly scheduled structured sessions with weekly collaboration; 2) sessions are sustained for at least one year; and 3) consistent and prescriptive support are provided that helps teachers to integrate new pedagogy into their curriculum and transform their practice.

**Table 1: Differences between Three Types of Professional Development**

<b>Peer Coaching and Mentoring</b>	<b>Communities of Practice</b>	<b>Sustainable Professional development</b>
Guidance for effective intervention and change of practice dependent on the knowledge and skills of the coach	Knowledge and skills that are entrenched in learning community are shared, added to the repertoire and constantly circulating	Designed for facilitation of knowledge acquisition that is reflective of current research-based knowledge and skills
Others gathering data on a teacher's practice which is dependent on their subjectivity	No data is gathered on practice. Teachers practice is just shared through discourse	Teachers gathering own data of their practice, analyzing the data and deciding on the best way to modify their practice
Sometimes feedback not given and coaches' schedules and responsibilities may prevent follow-up	Feedback given though informal discourse and sharing of narratives through daily professional conversations	Regular follow-up, support and feedback built into the professional development
Could promote collegiality and collaboration without clear direction and purpose	Could promote collegiality and collaboration without clear direction and purpose	Promotes collegiality and collaboration with defined goals and a common purpose
Many times peer coaching is not structured to be sustainable for extended periods so it may not have a strong impact in changing teachers' practice.	Social engagement is more important than the minimum time needed for teachers to change, but change could be an effect of sharing.	Designed for teachers to integrate new skills to change their practice and is sustained over time for at least a year.
Could influence teachers to be resistant to change if coach does not support the change	Could either facilitate or frustrate emergent practices and identity. Ways of teaching may be so strongly embedded that they are resistant to shared enterprise	Facilitates the redefining and reshaping of teachers beliefs, identity and refining of their practice
Knowledge and skills imparted through coaching may not reflect current research and are only effective if the receiver in the coaching relationship finds it useful.	Same pool of knowledge is circulating so if knowledge is flawed the whole repertoire is flawed as teachers propagate the community's practice	Knowledge and skills based on current research that teachers use to integrate new skills into their teaching
Could be informal and not structured	Informal discourse that may or not be held regularly	Has formal and structured sessions
<b>Common Attributes</b> <ol style="list-style-type: none"> <li>1. Situated in the teachers professional learning communities</li> <li>2. Has some element of sustainability though extended sessions</li> <li>3. Collaboration and mutual engagement (learning by doing)</li> </ol>		

## 7. Technology Enhanced Formative Assessment (TEFA)

Technology Enhanced Formative Assessment (TEFA) is being implemented under the Teacher Learning of Technology Enhanced Formative Assessment (TLT) Project. The goal of TLT is to conduct research and construct a model of teacher learning of Technology Enhanced Formative Assessment (TEFA). TLT is a project that is implemented by the University of Massachusetts Amherst (UMass) and is funded by the National Science Foundation. The TEFA project provides professional development and support for teachers to learn TEFA pedagogy and facilitate their implementation of TEFA into the curriculum.

The three main goals of the TLT Project are to:

1. Understand teacher learning of TEFA-based pedagogy;
2. Understand effective and efficient methods of teacher professional development of TEFA;
3. Develop tools and techniques for evaluation of teachers' mastery and implementation of TEFA (TLT, NSF TPC-0456124; Leonard, et al., 2004; Beatty, et al., 2008).

TEFA is innovative pedagogy that is student-centered, interactive, question-driven instruction that utilizes question cycles to promote dialogical discourse and promote formative assessment. TEFA pedagogy develops students' conceptual understanding, develops student problem solving skills, facilitates generation of knowledge and gives teachers formative tools to adjust instruction to better meet the needs of the students.

TEFA utilizes the technology of classroom response systems (CRS) as a tool to facilitate question cycles and enhance dialogical discourse in the classroom. CRS are handheld response systems that use interactive wireless transmitters commonly called "clickers" that students use to choose from a selection of answers. CRS are also referred to as personal response systems (PRS). TEFA has the potential to transform teachers' practice through their use of technology enhanced formative assessment that allows students to construct and shape their own knowledge and gives teachers the feedback that is necessary to modify their instruction.

TEFA pedagogy has its foundation in the development of PRS pedagogy by the University of Massachusetts Physics Education Research Group (UMPERG) (Dufresne, Gerace, Leonard & Wenk, 1996; 1997). From 1996, PRS pedagogy continued to be

developed and continued to evolve and was later called Assessing-to-Learn (A2L: Dufresne, Gerace, Mestre & Leonard, 2000) and sometimes referred to as Question-Driven Instruction (Beatty, Leonard, Gerace & Dufresne, 2006; Beatty, et al., 2008).

a. **Principles of TEFA**

There are four theoretical constructs of TEFA which are: cognition and conceptual learning, social aspects of learning, student attitudes and motivation, and formative assessment. These constructs of TEFA are imbedded in the four principles of TEFA. The four principles of TEFA which are enacted through question cycles and CRS facilitation of these question cycles are:

1. Using *question-driven instruction* to probe students' conceptualizations and focus student learning.
2. Using *dialogical discourse* to develop students' understanding, developing students' thought processes and expand their knowledge.
3. Using *formative assessment* to identify students' conceptions and reasoning and use the feedback from students to modify the lesson to address any misconceptions.
4. Using *meta communication* to communicate the purpose of learning so that students could have ownership in the learning process and be more invested in their learning.

(Beatty, et al., 2008)

b. **Benefits of TEFA**

TEFA exposes teachers to current research-based pedagogy which promote student-centered teaching methods that encourage students to be proactive learners. TEFA

encourages dialogical discourse that assists students to apply their knowledge and make the mental leap to higher level thinking skills by processing and justifying their answers. The effective implementation of TEFA could improve students' reasoning and problem solving skills while expanding their knowledge. TEFA uses question cycles facilitated by CRS to provide immediate and critical feedback for teachers and students while giving students the element of anonymity when responding to questions (Beatty, Leonard, Gerace & Dufresne, 2006; Beatty, et al., 2008).

Regularly assessing student comprehension and generating student discussion are the hallmarks of quality instruction (Brickman, 2006). TEFA is an invaluable tool that generates discussion that provides formative assessment that teachers could use to assess and monitor students' understanding (A2L: Dufresne, Gerace, Mestre & Leonard, 2000). Formative assessment is the use of evidence of students' preconceptions derived from feedback from students to adapt the teaching to meet student needs. The development of formative assessment skills in teachers could raise student achievement (Black & Wiliam, 1998b). Some sources of feedback that could be used for formative assessment are questions and discourse. Monitoring students' understanding by asking questions, both prepared and spontaneous, and making immediate adjustments to their teaching to respond to students' responses (McQuin, 2004; Keeler, 2006, Brickman, 2006) are desirable and much needed skills for effective agile teachers. Quality discourse between teacher and students results in deeper discussion of conceptual learning. In effective formative assessment the teacher uses the content of the feedback derived from the discussion to analyze the context in which

students' assumptions, motivations and self perceptions occur (Black & Wiliam, 1998a).

It is very advantageous for teachers to see how students think, although this goal is elusive and often difficult. Utilizing ongoing formative assessment facilitated by the classroom response systems help teachers know what students are thinking and assess their thought processes (Herreid, 2006). This ability to assess students' thought processes is one of the fundamental pillars of TEFA. Technology plays a significant role in TEFA. CRS is a technological tool that is used to facilitate and enhance the question cycle of TEFA. CRS has the capability to help instructors and the students themselves visualize students' thinking so that decisions could be made to support appropriate courses of action for students' learning (Johnson & McLeod, 2004).

## **8. Technology**

This technology section will feature insights from research on CRS, technology barriers and constraints to technology integration, teachers' beliefs about technology and professional development for technology.

### **a. Classroom Response Systems (CRS)**

Classroom Response Systems (CRS) are hand-held interactive wireless transmitters commonly called "clickers" that students use to select answers from a choice of options. CRS are also known as Classroom Performance Systems (CPS) or Personal Response Systems (PRS). CRS has emerged as an important teaching and learning tool with significant benefits. Numerous models of professional development and ways of integrating technology into teaching have been noted in previous research however, the literature is very limited when it comes to examining professional

development that gives focus to integrating classroom response systems (CRS) into the teaching of science and math at the pre-college level.

In CRS literature, there are “general recommendations of CRS use, and technical descriptions and comparisons” of various systems (Fies & Marshall, 2006, p. 103), however the existing literature “rarely describe conditions of use such as purely formative assessment that serves to scaffold instruction” (Fies & Marshall, 2006, p. 101). Additionally, college students’ responses in individual and group modalities and the conditions that elicited the responses to specific questions have been studied in the CRS literature (Fies & Marshall, 2006), but there does not seem to be any literature that combines TEFA pedagogy of using question cycles to promote dialogical discourse with CRS as a tool to reshape students’ thinking (Beatty, et al., 2008).

CRS is one of the newer technologies that are in use in institutions of learning. Colleges and universities have been using CRS for approximately a decade to get students more engaged in their learning and students have come to expect CRS in large lecture hall settings (Hatch, et al, 2005). CRS have been credited with assisting college lecture halls to become effective student-centered environments where students are more engaged and more apt to participate in the class than they were before the use of this technology (Herreid, 2006).

The use of CRS could also promote students’ generation of knowledge in a context that is more meaningful and could assist instructors to identify and address misconceptions and monitor students’ learning and progress. CRS has the potential to revolutionize the teaching of science and mathematics and could improve teachers’ practice by making it more student-centered and student directed (Brickman, 2006).

CRS technology and the associated pedagogy to probe students understanding is used in large college lecture halls to have immediate access to assessment and classroom research techniques which could be used formatively to help instructors connect the way they teach with how students learn. In colleges CRS technology enabled instructors to receive quantitative feedback that they used to pace their courses to better meet students' needs while students welcomed the opportunities CRS afforded them to discuss and reflect on their understanding of the material. CRS technology helped college instructors to successfully manage and encourage meaningful classroom discussion while providing immediate and regular assessment of student comprehension in large lecture halls (Brewer, 2004; Skiba, 2006; Brickman, 2006).

CRS use at the college level have also been credited with increasing enthusiasm and motivation of students. Another benefit of CRS is that it provides students with indicators of both their progress and the learning progress of the class. The interactive nature of CRS has resulted in college students coming better prepared to class and in instructors being more mindful of the need for questions to be challenging, thought provoking and stimulating. College students, particularly in large science classes reported that CRS facilitated their understanding of material and helped them prepare for exams (Herreid, 2006). Conducting research of the SSSPD model will examine the role of this model in helping high school teachers realize the many benefits of using CRS that have been documented at the college level.

#### **b. Technology Barriers and Constraints**

It is important to recognize and understand the relationship between technology and learning and the impact of this relationship in improving our educational system.

Development of learning environments where students can generate knowledge with the enablement of technology that facilitates learners exploring, expanding and enhancing their own capabilities is essential for improved educational effectiveness (Ertmer, 1999; Hokanson & Hooper, 2004). This generative quality of technology makes TEFA pedagogy facilitated by CRS a viable tool to help teachers model students' learning and encourage students to become proactive learners. Barriers and constraints that teachers have with integrating technology into their teaching could have a negative impact on the successful integration of TEFA pedagogy as they learn to use CRS as a tool to implement TEFA pedagogy.

There are many barriers and constraints that may impede teachers' integration of technology into the curriculum. In a study that examined computer use by teachers and students in two high schools in California, Cuban, et al (2001) sought to answer the question of why teachers who use computers for instruction typically use the technology to sustain common teaching practices. The evidence pointed to several barriers that impeded more innovative use of technology. These barriers included: technology training was seldom offered at convenient times; most training was too generic and was rarely specific to the needs of the teachers; and teachers did not have the time to find and evaluate software. There was also significant impact of contextual factors, particularly the structure of the school day, the culture of the school, and the location of computers. Although this study examined the use of computers, the findings could also be applied to teacher usage of other technologies like CRS.

These barriers could also include lack of interest, lack of knowledge, lack of confidence in using the new technology, teachers unwillingness to change, insufficient

time to plan instruction, problems integrating technology into curriculum, lack of access to computers and software and lack of adequate training and technical support (Ertmer, 1999; Earle, 2002; Hokanson & Hooper, 2004; Wood et al, 2005). Ertmer (1999) categorized these barriers into two groups. These barriers were first order barriers which included problems with hardware, access to the technology, lack of administrative support and lack of effective technical support. The second set of barriers were identified as second order barriers which were teachers' beliefs and perceptions, changes in pedagogy and teachers' personal preferences in their teaching styles (Ertmer, 1999). Second order barriers have a greater influence than first order barriers in impeding teachers' integration of technology into instruction because they are usually deeply embedded in teachers' beliefs and perceptions about teaching. The teachers may not even be aware of their embedded beliefs and practices which sometimes result in teachers unconsciously resisting the technology (Ertmer, 1999).

**c. Teachers' Beliefs about Technology**

Teachers' reactions to these constraints and barriers are partly based on their beliefs about what constitutes effective classroom practice (Ertmer, 1999). Teachers' beliefs are essential in considering how a teacher teaches, thinks, and learns. Teachers' technology beliefs are influenced by their teaching philosophy. Responding to teachers' beliefs toward technologies is a critical component in meeting teachers' technology needs (Sugar, et al, 2004). The importance of considering teachers' beliefs about technology is echoed in a report of four case studies that were conducted in the Netherlands that investigated teachers' beliefs about implementing technology and its role in education. The findings of the study indicated that teachers have strong beliefs

about how their subject should be taught and these beliefs appear to change very slowly (Veen, 1993). Teachers therefore, are more likely to adopt new technology and be successful at it if they can use the new technology in accordance with their existing beliefs and practices and if there is properly differentiated technology training for teachers (Veen, 1993; Mumtaz, 2000).

In addition to teachers' existing beliefs and practices, other factors that influence teachers' development and implementation of technology skills are: the extent to which they value those skills and see them as relevant and useful, and the extent to which the skills are practiced and used in their work (Simpson, et al, 1999). Research reveals that teachers must be personally convinced of the benefits of technology and must see the utility of using a particular technology before they are willing to use technology as an instructional tool to enhance students' learning. Teachers want to know what impact the technology will have on students' learning outcomes. Successful technology adoption in teachers' classrooms is dependent upon providing an individualized, differentiated process of training and implementation instead that takes into consideration the needs of all participants. Teachers must see how technology fits within their teaching context and how it could be situated within their content area (Sugar, et al, 2004). Teachers need to work collaboratively in identifying and solving problems that may impede their effective integration of technology into their practice. Barron (2000) in writing about students achieving collaboration in problem-solving groups stated that working collaboratively on interesting problems can result in tangible accomplishments which include a deeper engagement in subject matter, facilitation of a sense agency and the

promotion of constructive dialogue. This is also true for teachers in the role of students learning to integrate new technology into their teaching.

In order for technology integration to be successful, there must be changes and reorientations in the teachers' practice. These changes are more dependent on human factors which are internalized by the teacher and less dependent on first order barriers which are external factors (Ertmer, 1999). Successful integration of technology into teachers' practice necessitate addressing pedagogical, curricular and methodical issues that the teachers may have (Hokanson & Hooper, 2004). Addressing and resolving the constraints and barriers in these three areas is also essential for the effective use of CRS technology as an integration tool for TEFA pedagogy.

#### **d. Professional Development for Technology**

Effective integration of technology into teaching could improve teaching and learning. There is a critical need for professional development to be designed to enable teachers to successfully integrate new technology into their classrooms. Some of the benefits of integrating hand-held technology into the classroom are teachers having a better awareness of students' learning, an increase of students' engagement and students being better informed of their own learning (Irving, Sanalan & Shirley, 2008; Sanalan, Irving, Pape & Owens, 2008). With the integration of any new technology into the classroom, teachers have to change their way of being and their way of doing (Barron, 2000) in order to be skilled in new pedagogies that use technology to improve student achievement in science and math. To meet this demand, teachers are seeking "effective pedagogical strategies to take advantage of the considerable power of technology" (Linn, 2004, p.10). In this era of technological innovation there is a demand for

professional development to assist teachers with integrating technology into their practice and classroom integration opportunities for educators have become an exciting area of growth (Crawford, 2000; Linn, 2004).

Concern has been voiced in literature that in many instances teachers that attend professional development activities are not effectively implementing technology to supplement their teaching and that what teachers learn is not sustained over time (Ertmer, 1999; Ascione, 2006). Although many teachers use the computer and other technologies, in many cases technology has sustained instead of altered their teaching practice and the teachers are reluctant to integrate any other communication technology into their classes (Cuban, Kirkpatrick & Peck, 2001).

One of the ways to combat this resistance to change and other constraints and barriers to integration of technology is to implement effective sustained professional development. Staff development is critical for teachers to successfully integrate new pedagogy and new technology into their teaching. There is a link between staff development and increased student achievement (Killion, 1999). Teachers' influence on student learning is noted in previous research, however the literature is limited when it comes to making similar linkages to teachers' classroom uses of technology (Ertmer, 2005).

It is important to look beyond traditional training methods in understanding how technology can be used to facilitate learning (Rosenberg, 2004, p. 196). Rosenberg (2004) discussed five interdependent pillars for implementing and maintaining the use of technology in teaching. These pillars were: training, knowledge management, communities of practice, performance support, and talent alignment. Available support

increased the frequency of use of technology by teachers (Hernandez-Ramos, 2005; Bauer & Kenton, 2005). Therefore, all of these factors should be embedded into professional development geared to assisting teachers to integrate technology into their practice. The report on “Technology in Schools: What the Research Says”, which is a new meta-study on use and effectiveness of classroom technologies, concluded that educators did not make as much effort as they could have in documenting how the technology affected students’ learning, the way teachers used the technology and how efficient the use of the technology was. Therefore “the real potential of technology for improving learning remains largely untapped in schools today” (Ascione, 2006).

The concerns in the literature about barriers that may impede the use of PRS to facilitate TEFA and about effective professional development supports the need for additional research of professional development models that are designed to help teachers change and sustain their practice as they integrate new pedagogy and technology into their teaching. SSSPD could be a viable model for addressing these concerns because it has the potential of assisting teachers to change their pedagogical practices to integrate TEFA and PRS by:

1. providing weekly sessions comprised of a PD course and Action Research focus groups that is sustained on the school campus for three years;
2. providing collaborative opportunities for teachers to draw on the expertise of university faculty to learn and implement current research-based knowledge and skills;
3. providing regular feedback, follow-up and support;

4. facilitating the redefining and reshaping of teachers' beliefs and assisting them to refine their practice.

There has been very extensive research in the use of classroom response systems at the college level but very little research at the pre-college level. More research is definitely needed to inform the literature of the potential of PRS to facilitate Technology Enhanced Formative Assessment (TEFA) pedagogy in transforming the way teachers teach at the pre-college level. There is also a critical need for research to examine the role of sustained professional development in assisting teachers to realize the potential of TEFA pedagogy coupled with the technology of PRS for improving teaching and learning.

More research is also needed about teachers' philosophy, beliefs and perspectives as they could affect teachers' implementation of new pedagogy. Teachers' philosophy, beliefs and perspectives are influential factors that have an impact on teachers changing their practice (Veen, 1993; Mumtaz, 2000) as their beliefs and perspectives determine what they value (Simpson, et al, 1999). Teachers' philosophy, beliefs and perspectives could play a pivotal role in them changing their practice, therefore it is important to study the impact that sustained school situated professional development (SSSPD) have on altering and changing teachers' philosophy, beliefs and perspectives.

## **9. Teachers' Philosophy, Beliefs and Perspectives**

The educational literature discusses the influence of perspectives and beliefs on teachers practice. It is important to gain insights about teachers' beliefs, philosophies and perspectives about their practice. It is equally important to look at teachers' beliefs and educational practices whenever teaching and learning is going to be examined. It is

also imperative to examine the link between teachers' views on teaching and learning and their actual classroom practices. Teachers' life experiences, school experiences, personal interactions and a variety of other experiences and processes are the sources of teachers' beliefs and values.

A teacher's values guide his or her practice and cement his or her content and pedagogical knowledge into practical pedagogical content knowledge (Shulman 1987). In Shulman's (1987) "Model of Pedagogical Reasoning and Action" the two categories in his representation of teaching are: pedagogical content knowledge and the beliefs and values that teachers hold of their experiences which guide their practice. Pedagogical content knowledge is the amalgamation of pedagogy and content. The teachers' beliefs, values and pedagogical content knowledge are closely integrated. How teachers' values and beliefs cement pedagogy and content to create practical and powerful pedagogical content knowledge is demonstrated in the teachers practice (Gudmundsdottir, 1987, 1995; Shulman, 1987, 1990).

Beliefs and values penetrate the core of how teachers define themselves, therefore, they remain, and are intricately woven into everything that teachers do in their practice. Although values do not prescribe precisely what we ought to do, they have a strong influence on a person's actions by ruling out certain courses of action and sensitizing us to situations that are relevant to the frame of reference of our value system. A person's values and beliefs can be described as their personal curriculum which is used to interpret different situations that teachers encounter in their practice and decide on a course of action that they would take (Gudmundsdottir, 1987, 1995; Shulman, 1987, 1990; Haney, et al, 2003; Levin & Wadmany 2007). Teachers' values

are an integral part of their teaching practice and influences all aspects of their practice (Gudmundsdottir, 1987, 1995; Shulman, 1987, 1990; Haney, et al, 2003; Levin & Wadmany 2007). Beliefs about teaching are well established by the time a teacher attends college. The earlier a belief is incorporated into the belief structure of a person the harder it is to change (Haney, et al, 2003; Levin & Wadmany 2007).

Teachers' beliefs about what constitutes good and effective learning practices determine how they will teach students (Gudmundsdottir, 1987, 1995; Shulman, 1987, 1990; Haney, et al, 2003; Levin & Wadmany 2007). Research has been done on analyzing and interpreting teachers' beliefs about teaching and learning and how they influence the methods that teachers use in the classroom (Levin & Wadmany 2007). Teachers' knowledge about the nature of science, their roles as teachers and their students roles as learners are important to understand students' learning processes and to help them develop as proactive learners (Brickhouse, 1989,1990,1991). It is important to investigate the implicit linkages between teachers' perceptions about teaching and learning and the actuality of their classroom practice (Levin & Wadmany 2007).

A teacher's identity and image as a teacher are shaped by the teacher's philosophy and beliefs. The development of a teacher's identity is a dynamic and continuous process as multiple experiences continually mold, inform and reform the teacher (Levin & Wadmany, 2007). Multiple influences including role models, previous teaching experiences, education classes, and personal experiences all have a strong impact on how teachers construct an explicit view of themselves as teachers (Page, et al, 2004).

There is a critical relationship between the beliefs and perceptions of teachers on the instructional decisions that they make (Lumpe & Chambers, 2000). “Beliefs are filters that guide teachers during instruction mode under curricular, decision-making.” (Levin & Wadmany 2007, p.158). Teachers’ beliefs strongly influence their classroom practices and affect how they implement new pedagogy and new innovations. Teachers’ beliefs are the determinant of whether a teacher adopts new teaching methods, which methods are adopted and how and why the methods are adopted (Haney, et al, 2003; Levin & Wadmany 2007). The teacher’s perspectives and beliefs also determine how the teacher adapts the new methodology to the classroom environment, processes and goals. Teachers’ perceptions on teaching and learning generally range from imparting knowledge to students or information presentation to facilitation of student learning and encouraging students to construct knowledge (Levin & Wadmany, 2007).

Teachers’ beliefs reflect their former conviction and their philosophy on opinions about teaching and learning. “Teachers beliefs are precursors to change” (Haney, et al, 2003, p.367). Belief clusters are several beliefs intermingled around a particular situation, which forms the attitudes of the teacher. The attitudes then become the agenda for action. Beliefs and perspectives play an integral role in the teachers’ definition of tasks and in their selecting cognitive tools with which to interpret, plan and make decisions (Haney, et al, 2003).

Teachers’ beliefs are an important consideration by persons planning professional development (Loucks-Horsley 1998). Many professional development activities have been designed to change teachers’ model of operations in the classroom and to get them to implement new pedagogy and new approaches. Teachers come to

professional development activities with certain beliefs, attitudes and behaviors that will affect their implementation of any new pedagogy, any future teacher behaviors and student learning (Lumpe & Chambers, 2001). Teachers will only adopt new practices that are consistent with their beliefs and perspectives. Teachers' perspectives about integrating technology into their practice could present a formidable barrier to using technology in the classroom (Lumpe & Chambers, 2001). Changing teachers, paradigm and mode of operation is a very complex process (Levin & Wadmany, 2007). It is not easy for teachers to implement new teaching approaches. For integration of new pedagogy and innovations to be successful, they must be supportive of and must positively influence existing beliefs or have a very strong impact on changing the teacher's existing beliefs. Additionally, teachers must be committed and prepared to enact their beliefs despite any constraints that may impede successful implementation (King, 2007).

Sustained school situated professional development (SSSPD) is a model of professional development that could have a positive impact on altering teachers' perspectives and their belief systems. Further, SSSPD could also be instrumental in engendering change in teachers' practice as they integrate new pedagogy and technology into their practice. Research on SSSPD could reveal pertinent information on any relationship that may exist between changes made in teachers' philosophy, beliefs and perspectives and changes that they may make in their practice.

#### **10. SSSPD Model for the Pilot Study**

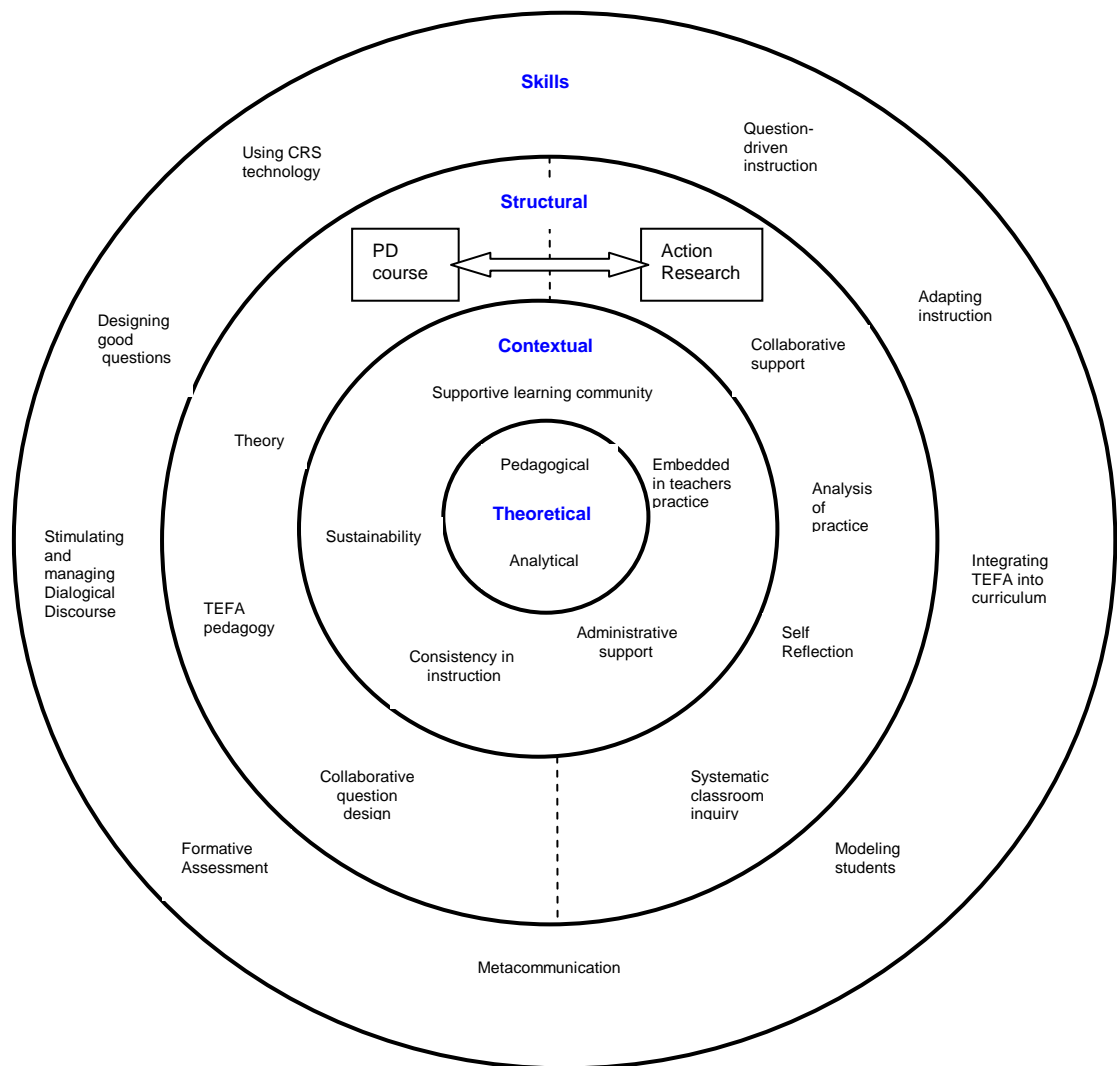
The Sustained School Situated Professional Development (SSSPD) model that was being utilized for the TEFA project was especially useful in helping teachers

integrate new pedagogy like TEFA pedagogy into their teaching. The professional development model employed for TEFA was intensive and extensive professional development that was structured to help teachers develop a broad range of skills and address any difficulties that they may experience which may impede the implementation of TEFA pedagogy.

The SSSPD model that was utilized for the TEFA project was a four-tiered model. This four tier model is the depiction of this researcher and reflects how I perceive the framework of the TEFA professional development model that is the focus of this study. The first tier is the *theoretical* constructs on which TEFA is grounded and which served as the core for the design, implementation and analysis of TEFA. The four theoretical constructs of TEFA were: cognition and conceptual learning, social aspects of learning, student attitudes and motivation, and formative assessment. All components and outcomes of TEFA radiate from and revolve around the theoretical core. The second tier was the *contextual* framework that situated TEFA at the school where the participants practiced, where teachers learned and used TEFA pedagogy in a supportive formative learning community. Next is the third tier which was the *structural* framework of the model that consisted of a PD course and action research group which interacted with and supported each other. The fourth and final level was the *skills* tier which show the skills which participants in the SSSPD were expected to attain for TEFA mastery. Figure 1 on the next page shows the four tiers of the SSSPD model that was used for TEFA.

The TEFA SSSPD model consisted of a four day initial summer workshop held

for 6 hours each day which gave participants an overview of the TEFA and initial practice crafting TEFA questions and using the PRS technology. Then sustained professional development was implemented via weekly meetings that were held after school which consisted of a PD course three times a month and action research group



**Figure 1: SSSPD Model**

sessions once a month. The duration of the weekly sessions was two hours and they were conducted for the entire academic year. The action research sessions were

sustained for the second and third year of the SSSPD. The SSSPD model being studied was facilitated by faculty from the University of Massachusetts, Amherst.

One of the strengths of the SSSPD model was working with all teachers or with the majority of teachers in the science department of participating schools. This was a holistic approach to engendering school wide change in science instruction and promoting consistency in learning science for students of participants (Leonard, et al., 2004). The SSSPD model gave the participants opportunities to learn the theoretical constructs of TEFA pedagogy together and adapt their practice while integrating TEFA in a formative environment that facilitated maintenance and sustainability of the teachers' TEFA pedagogical skills (Fraser, 2005; Evan, 2002; Killion, 1999). Another strength of the SSSPD model that was studied was that it was designed and structured to address most of the constraints and barriers documented in the literature. The SSSPD model was designed to provide support for learning TEFA pedagogy and assistance with curricular and methodological issues while giving technical assistance for the teachers to integrate CRS into their teaching (Sanalan, Irving, Pape & Owens, 2008).

Action research has an important role in SSSPD as it promotes the sharing and generation of knowledge and is characteristically collaborative, collective, diagnostic, critical and self-reflective. The focus on collaborative and consistent sharing and discussion of anecdotes, self reflection and systematic classroom inquiry that teachers use to explore, define and refine their practice (Feldman & Capobianco, 2007) are benchmarks of the TEFA SSSPD model. As teachers are engaged on their practice, intellectual engagement and collaboration generates further inquiry. Self reflection and analysis through action research help teachers to be self-directed learners as they operate

in the dual role of teacher and as a researcher studying their own methods of practice (Altrichter, Posch & Somekh, 1993; Feldman & Capobianco, 2000; Feldman, Paugh & Mills, 2004, Somekh, 2006). Action Research assists teachers to evaluate their practice and integrate new skills while allowing critical evaluation of the teachers' practice to be left up to them. Action research also gives them the opportunity to self-regulate what they are doing and implement what is needed for them to effectively improve their practice (Altrichter, Posch & Somekh, 1993; Feldman & Capobianco, 2000; Feldman, Paugh & Mills, 2004, Somekh, 2006). It is very important for teachers to become self managing, self monitoring and self modifying as they develop as self directed learners (Costa & Garmston, 2002).

The SSSPD model builds on the foundation of the teachers' identity, their past experiences, their scholarship, their desire for professional expertise, their beliefs about teaching and learning and their perceived needs. SSSPD builds teachers' skills and promotes change in teachers' practice in a sustained, supportive and formative learning environment (Loucks-Horsley et al., 1998; Supovich & Turner, 2000; Johnson et al, 2007). The axle on which change revolves in the teachers' practice is the teachers' ways of knowing and ways of doing which goes through various processes and results in teachers redefining who they are as teachers and redefining their practice (Kohler, et al., 1997).

#### **a. Benefits of SSSPD**

This study illuminated benefits of the SSSPD for the participant in this research and for other persons who participated in this model of professional development. The findings in this study reflected benefits of the SSSPD model that include:

- On-going learning for teachers while encouraging teachers to reflect on and critically analyze their practice through action research;
- Continuous knowledge exchange and learning that is crafted by the specificities of teachers' practice and that evolves over time because the collaborative nature of SSSPD;
- Provision of support for the integration of new knowledge and skills into teachers' practice;
- Consistent, structured and timely follow-up;
- Assistance given to teachers to develop context and content appropriate solutions to problems they may encounter;
- Distillation and codifying of lessons of good practice;
- Strengthening of teachers' practice and the resultant improvement of student learning;
- Sustainability of the new knowledge and skills of the teachers over time;
- Built in tools for measuring the effectiveness of SSSPD that gives this type of professional development model a self-regulating attribute;
- Meeting the situated needs of teachers while providing social, emotional and professional support;
- Symbiotic and reciprocal while teacher benefit from the coaching of university faculty while providing university faculty insights about teachers' practice, their beliefs about teaching and learning, their needs and their learning trajectories.

In the SSSPD there is potential for symbiotic exchange of information between the university faculty imparting knowledge and skills about new educational initiatives

and the teachers imparting knowledge about teaching and learning from the perspective of practicing teachers to the university faculty. This potential symbiotic exchange could provide insights and could inform the practice of the university faculty as it relates to their interaction with teachers. This symbiotic exchange could also help inform the teacher education program at the university level.

The SSSPD model used for the TEFA project was extensive sustained professional development that was designed to assist teachers to develop skills that are embedded in the four principles of TEFA. The SSSPD model is espoused in current research that the university faculty had a pivotal role in developing. The main features of SSSPD: 1) being situated at the school where teachers practice; 2) having weekly structured professional development facilitated by university faculty; 3) being sustained for at least one year; 4) providing consistent, timely and prescriptive support; and 5) providing opportunities for participants to systematically assess themselves, build on their strengths and address their weaknesses as they learn new pedagogy are strong attributes that could facilitate change in the teachers' thinking and practice while they learn new pedagogy.

The collaboration, consistent feedback, follow-up and support of the professional development course and action research in the SSSPD model could facilitate the change of teachers' beliefs, philosophies and practices that may be resistant to integrating technology. SSSPD could help teachers use new technology to support new pedagogic practices. The findings from this dissertation showed that SSSPD could overcome barriers to change experienced by teachers learning new pedagogy through strategic and prescriptive action (Somekh, 2006). The SSSPD model has many

potential benefits

that could assist teachers to improve their practice and could be instrumental in sustaining changes over time. Research of the SSSPD model could add to the literature on sustainable professional development as it illuminated the impact that SSSPD had on addressing the tensions, constraints and barriers that may serve as obstacles in implementing TEFA pedagogy with PRS.

### **C. Conclusion**

Review of literature of professional development models revealed distinguishing characteristics of each model, described their operational frameworks and pointed out similarities and differences between the models. The professional development models reviewed in the literature were “one-shot” workshops, peer coaching and mentoring, communities of practice and action research. The Sustained School Situated Professional Development (SSSPD) model was described and compared to the other four PD models. The PD models were analyzed and discussed in light of the capability of each model to improve teaching and effect change that was sustained over time.

Three of the PD models: peer mentoring and coaching, communities of practice and action research create professional learning communities that are situated in the place of the teachers’ practice and could be instrumental in teachers changing their practice. However, there were two main differences between SSSPD and the other school situated professional development models. The first difference is that SSSPD has frequently structured sessions which are specifically designed to teach practitioners a new pedagogy and provide long term support for at least one year which could help

teachers master and retain new skills and could support the sustainability of those skills over time. Secondly, the SSSPD model is comprised of a PD course and action research which provide collaborative scaffolding that is built on the scholarship, value and contributions of the participants.

Effective professional development organizes teachers into learning communities that are seeking continuous and sustained instructional improvement (McChesney, 1998; Gusky, 2000; Supervich & Turner, 2000; Evans, 2002; Fraser, 2005). Professional development that is sustained over time assists teachers to address change as they work towards their own goals of gaining professional expertise in integrating new pedagogy into their teaching. When compared to the other four professional development models, SSSPD could have a better potential for engendering change in the teachers' thinking and practice while they learn a new pedagogy.

Although research has been conducted on some models of school situated sustained professional development there has been virtually no comparative study on SSSPD in education that consists of action research and a professional development course. Also lacking in the literature are professional development models that provide situated professional development sustainability through the sequel provision of instruction and support by university faculty to assist teachers to integrate new pedagogy into their practice. Literature of SSSPD's designed to provide sustained training to help high school teachers integrate TEFA pedagogy utilizing PRS into their practice is nearly non-existent. The lack of research of TEFA pedagogy facilitated by PRS underscored a need to study this new pedagogical methodology. The limited research makes it difficult to identify commonalities and differences among school situated models like

peer coaching and communities of practice and SSSPD. Consequently, it is difficult to develop a model for sustained professional development that is applicable and practical in a wide range of continuous professional development activities in education.

The gaps in the literature with regard to models for SSSPD indicate the need for additional research. More research is needed to explore the efficacy of sustained and professional development that meets the situated needs of teachers in their teaching and learning environment. It is hoped that the exploration of the SSSPD model will inform the existing research by delineating the components of SSSPD; outlining the outcomes and the benefits of this sustained school situated professional development model; give insights about the change process that teachers experience while learning new pedagogy and illuminate the potential of SSSPD for improving teaching and learning.

There is definitely a need for more research to study the pre-college use of PRS and its affect on enhancing formative assessment. Further research is needed to explore the affect of SSSPD on teachers' learning of TEFA pedagogy and how they integrate TEFA into the teaching of science and mathematics. Additional research will give insights of teachers learning and use of TEFA and CRS and the processes they go through as they integrate TEFA pedagogy into their practice. The role of action research in the teachers' integration of TEFA and PRS will add to the literature on SSSPD's. This study could broaden the research base for professional development components inclusive of presentation of theory, modeling or demonstration of effective integration of TEFA pedagogy and effective use of PRS. These are all essential factors that appear to affect teachers' implementation of an innovation (Guskey & Sparks, 1991). This study of the SSSPD model generated new knowledge that will add to the literature and

could assist in further refining the SSSPD professional development model to make it as effective as possible for teachers integrating the TEFA pedagogy in the future.

## **CHAPTER III**

### **RESEARCH DESIGN AND IMPLEMENTATION**

#### **A. Introduction**

This study was an explorative and descriptive case study that explored the role and impact of Sustained School-situated Professional Development (SSSPD) on teacher learning of Technology Enhanced Formative Assessment (TEFA) and teacher change as TEFA pedagogy was integrated into a high school science teacher's practice. The study described how the participant's practice evolved over a two year period by exploring different aspects of her practice, identifying exemplars of effective TEFA integration, tracing the development of these exemplars in the participant's practice and examining the enactment of these exemplars in the classroom of the participant. TEFA is formative assessment that is facilitated by personal response systems (PRS). PRS are hand-held, interactive infrared wireless transmitters commonly called "clickers" that are used to poll students' answers.

There is voluminous literature about teacher learning, teacher change, continuous professional development, formative assessment and classroom response systems. However, the literature seems to be non-existent when it comes to individual teacher learning of Technology Enhanced Formative Assessment (TEFA) pedagogy while participating in SSSPD. The findings from this case study could add to the research literature on the SSSPD models that engender teacher learning of new pedagogy and on teacher change in using new pedagogy to modify and transform their practice. This case study has implications for further defining and refining the SSSPD

model used to implement TEFA for future participants and for guiding future inquiry of teacher learning and teacher change during participation in SSSPD.

## **B. Case Study Research Methodology**

A case study is a research methodology that is an analytical study of the development of a case which may be an individual, a group or an institution (Yin, 2003a). This research was a single case study which was descriptive as well as exploratory that studied one participant's learning and integration of TEFA pedagogy into her practice. This case study was descriptive because it traced the sequence of events over time and aimed to discover key phenomena through empirical inquiry. The study was exploratory because the findings could be pertinent in developing hypotheses and prepositions that could guide further inquiry (Yin, 2003a).

Conscientious attention should be paid to the rigorous design and execution of a case study to overcome or counteract the traditional criticisms and caveats of using the case study method that have been espoused in the literature (Yin, 2003a). This case study followed Yin's (2003a) research design framework. The five components of Yin's research design framework are: 1) specifying the research question or questions; 2) stating existing propositions to the research questions; 3) defining the unit of analysis to be used to investigate the research questions; 4) articulating the logic of linking data to propositions; and 5) identifying the criteria for interpreting findings.

### **1. Research Questions**

As a reminder of the focus of this study, the research questions that guided this research are also mentioned in this chapter.

Central Question

What can be revealed about the impact of Sustained School Situated Professional Development (SSSPD) by studying teacher learning of Technology Enhanced Formative Assessment (TEFA) in a teacher who emerged as an exemplar?

#### Secondary Questions

- e) How has the participant's practice changed over a period of two years as she integrated TEFA pedagogy into her practice?
- f) Are there predictors that may facilitate change in the practice of this participant? If so, what are the predictors that assist the participant to integrate TEFA into her practice?
- g) How does the SSSPD model affect the participant's practice while implementing the TEFA pedagogy?
- h) How could the findings be used to develop a model of teacher change?

## **2. Existing Propositions**

There were initial assumptions that provided a rationale for this case study that guided the selection of data sources and that were used to define relevant information and to direct phenomena to be explored. It turned out that these assumptions were major findings about SSSPD. These initial assumptions were:

- a) SSSPD affords teachers the opportunity to examine and redefine beliefs and structures that are imbedded in their practice;
- b) Learning a new pedagogy in a supportive SSSPD environment would engender change in the teacher's thinking and practice;
- c) SSSPD supports, maintains and sustains effective adoption and integration of TEFA pedagogy.

### 3. Unit of Analysis

There was one participant that was examined in this case study. The participant was one of ten teachers participating in the SSSPD model who were learning to integrate the TEFA pedagogy into their teaching. All participants showed some degree of learning TEFA pedagogy and progress in integrating TEFA along various trajectories. However, one participant was the unit of analysis for this case study because that participant showed more progressive development of expertise in learning TEFA pedagogy and in integrating TEFA into her teaching than the other nine participants who participated in the SSSPD.

The participant emerged as an exemplar of TEFA practice after preliminary examination of numerous data sets that are data sources for this study. Several criteria were used for selecting the case – the participant as the unit of analysis. The first criterion was identifying exemplars of TEFA practice. In defining expertise in integrating TEFA into the participant's practice the questions that were considered were: What are exemplars of TEFA? Secondly, how are these exemplars enacted in the participant's practice? Thirdly, could the study of a single participant reveal key attributes and benefits of SSSPD, further define SSSPD and be predictive of exemplary outcomes in teachers participating in similar SSSPD models? (Yin, 2003b).

- a) *Identifying exemplars of TEFA practice* - The exemplars of TEFA integration are: i) ability to craft effective questions that expose misconceptions, foster learning and provide useful information for the teacher to modify instruction; ii) ability to encourage and facilitate whole class discussion that elicit thinking and generate learning; iii) ability to make real-time modifications to lessons that are guided by

feedback from students; iv) ability to model students by probing their conceptions to get a better understanding of their thought processes; and v) ability to empower students to be invested, proactive learners (Leonard, et al, 2004; Beatty, et al, 2008).

- b) *Exemplars enacted in participant's practice* – The study examined how and when were the exemplars enacted in the classroom of the participant by exploring the following factors: i) identification of predictors that caused the participant to be predisposed for effectively adopting and integrating TEFA. ii) types of activities and lessons in which exemplars were seen; iii) the enactment of exemplars in the classroom; and iv) the impact of exemplars on classroom interactions and on the classroom climate.
- c) *Definition, attributes and benefits of SSSPD* - Exploring the role of SSSPD in the:
  - i) participant's development of exemplars; and ii) change in the participant's practice and maintenance and sustainability of TEFA practice.

#### **4. Linking Data to Propositions**

Some variables of interest in linking data to propositions were:

- a) Participant's learning process and development of skills;
- b) Participant's ability to reflect on and analyze her practice;
- c) Participant's adaptability and willingness to change;
- d) Imbedded behaviors and beliefs that are resistant to change;
- e) Supportive frameworks of the SSSPD.

(See Appendix A).

## **5. Criteria for Interpreting Findings**

The following criteria were used to interpret the findings from this study:

- a) Data were examined in light of the research questions.
- b) Theories that were developed were used as a basis for explanations.
- c) Patterns emerging from the data were described and data were continuously analyzed to tease out linkages, relationships and interconnectedness of data from the seven quantitative and qualitative sources used in this study.

It is important to develop preliminary theoretical concepts to guide the design and data collection of a case study and to ground the study in appropriate research literature (Yin, 2003b). Theory involves formation of hypotheses of cause and effect relationships. Rather than being “an expression of a cause-effect relationship”, in descriptive case studies the “theory covers the scope and depth of the object (case) being described” (Yin, 2003b, p.23). Thoughtful consideration of theory leads to a sound and rigorous case study (Yin, 2003b). Theories guide the selection of the case to be studied, gives specificity to what is being explored in explorative case studies, defines a complete and appropriate description in a descriptive case study, determines the priority of data collection and data sources and facilitates the application and generalization of results to other cases (Yin, 2003b). There may be competing and complementary theories that provide the basis for substantive explanations and generalizations of those theories (Yin, 2003a). The theories that emerged from the examination of data were developed based on the expected outcomes that were explored in this case study which were:

Outcome 1

This study will show changes that occurred in the participant's practice and factors that facilitated the changes.

#### Outcome 2

This study will show why a teacher's involvement in SSSPD would result in teacher learning of TEFA pedagogy, support effective TEFA integration and promote change in the teacher's practice.

#### Outcome 3

This study will show how SSSPD facilitates the maintenance and sustainability of TEFA pedagogical content and skills in the participant.

A single case study cannot prove a hypothesis with the certainty of a "true experiment" but it could "suggest important clues to possible cause-and-effect relationships" (Yin, 2003b, p.69) and generate valuable information to inform educational research. Why does the utilization of case study methodology have a distinctive advantage for this research? A case study is a preferable research tool when the researcher has little control over events that occur and when "how" and "why" questions are being investigated (Yin, 2003a). The case study methodology was appropriate for this research because this case study examined *how* the participant developed as an expert user of TEFA over a period of two years. Additionally, this case study explored *how* beliefs, behaviors and actions of the participant changed and *why* the participant was predisposed to exemplary adoption of TEFA by identifying and exploring predictors of successful adoption.

One of the strengths of a case study is that it deals with a large variety of evidence and provides insights into operational linkages of the evidence that could be

traced over time (Yin, 2003a). The case study explored seven data sources which will be described in the Methods and Procedures section. The large variety of data sources and the evidence that these data revealed made this study a prime candidate for the utilization of case study research methodology. The case study is the method of choice when the phenomenon under study is not readily distinguishable from its context (Yin, 2003b). In the case of this study, determining teacher learning of TEFA and teacher change in the adoption of TEFA and the impact of SSSPD on these changes were difficult to isolate from other factors in the complexity of teaching that may have also contributed to those changes. Another advantage of using a case study is that case studies allow researchers to explore and better understand complex phenomena and investigate real life experiences while preserving the characteristics of those experiences (Yin, 2003a). This case study afforded this researcher the opportunity to investigate the complex phenomena of the participant changing her practice as she integrated TEFA while participating in SSSPD without changing the nuances of her learning process and experiences.

This research is a case study which subscribes to an interpretive paradigm. The case study design afforded the researcher the opportunity to study some aspects of the participant's practice from the participant's perspective. The case study design lends the participant's specificity, personal experience and individual perceptions to the research (Merriam, 1992).

What can be learned from the study of one participant who has emerged as an exemplar in learning and integrating TEFA pedagogy into her practice? Case study methodology is advantageous for this type of study because it is empirical inquiry that

investigates phenomena within the real-life context which in the case of this study is the classroom; the site of the participant's practice. A case study is an appropriate methodology when there is deliberate intention to investigate contextual conditions and circumstances that are considered pertinent to the study that have implications for guiding future inquiry and activities that are similar in nature. Case studies are also suitable when the boundaries between phenomena and context are not clearly defined or clearly evidenced (Yin, 2003a).

These characteristic features of case study research design lend themselves to the study of one participant because it traced the development of expertise of one teacher in the process of integrating TEFA pedagogy into curriculum. Secondly, it investigated the complexities and nuances of a teacher learning a new pedagogy and implementing it into her practice while exploring real life experiences of the participant. A further rationale for using case study methodology for this research was that there is no clear definition of the process in which the teacher's expertise evolved and by conducting this case study the researcher hoped to illuminate the evidence of the development of this expertise. Additionally, the intent of this study to discover key phenomena in the participant's learning process of TEFA pedagogy made it an appropriate research methodology for this study.

### **C. Methods and Procedures**

This section situates the research, describes the participant, discusses the researcher profile and the assumptions and biases that the researcher brought to the research. The researcher is the instrument in qualitative research and as such it is essential to know and understand the researcher's background, biases, and beliefs which

the researcher brings to the study (Rossman & Rallis, 2003). It is also important that the case study investigator is unbiased by pre-conceived ideas and not trapped by preconceived ideology and pre-conceptions (Yin, 2003a). Also included in this section are the methods and procedure for data collection. The methods used to organize and analyze the data are also outlined.

The research question sought to gain a better understanding of the participant's learning process of TEFA pedagogy and her integration of TEFA into her practice while participating in SSSPD. This case study examined the participant's learning and change over two years: from Spring 2006 to Spring 2008. Data collection began in May 2006 with the collection of baseline data and ended in April 2008. The times and frequencies of data collection will be discussed in the data collection section.

### **1. Setting**

The participant of this case study taught at a combined middle and high school that had grades 7-12 in Western Massachusetts, USA. The school had a student population of 726 composed of 94.8% White, 2.3% Asian/Pacific Islander, 1.5% Black, 1.1% Hispanic, and 0.3% American Indian and Alaskan Native. Nine percent of the students were classified as economically disadvantaged, 8.9% were on free or reduced lunch, 15.8% were students with disabilities and 0.7% were English Language Learners ([www.schoolmatters.com](http://www.schoolmatters.com)).

The participant in this case study was part of a group of ten teachers who were participating in a Sustained School Situated Professional Development (SSSPD) model. The teachers were participating in the SSSPD as part of the Technology Enhanced Formative Assessment (TEFA) Project which was a grant-funded project that was being

facilitated by faculty from the University of Massachusetts Amherst. The professional development was designed to help teachers learn the new TEFA pedagogy and assist them to integrate the pedagogy into their practice. The SSSPD was sustained over the two-year duration of this case study on the site of the participants' practice with weekly sessions for the first year and monthly sessions the second year. The teachers were learning to implement personal response systems (PRS) into their practice to enhance formative assessment to improve student learning. PRS are hand-held response systems that use interactive wireless transmitters commonly called "clickers" that students use to select from a choice of answers.

## **2. Participant**

Tracy was the sole participant of this study. Tracy was a veteran teacher with over 20 years of experience with a degree in Chemistry. During the two years of this case study, Tracy taught Chemistry X which was an advance placement (AP) course, Anatomy and AP Physiology. Advanced Placement courses are honor level courses designed as college preparatory courses. Tracy's students were a mixture of tenth, eleventh and twelfth grade students. Chemistry X was Tracy's targeted course for the integration of TEFA pedagogy. The duration of each class was 85 minutes.

## **3. Researcher's Profile**

This researcher is interested in the design and implementation of effective professional development for science inservice teachers. This avid interest in designing effective professional development led to my working as a research assistant for the TEFA project. As a research assistant, I assisted with the action research component of the SSSPD model, conducted interviews for all ten participants involved in the TEFA

project, and coded and analyzed data from the interviews. I believe that every effort should be made to help teachers to become more effective teachers by examining the many facets of their practice. I feel that studying the SSSPD model is a tool to examine teachers' practice and to explore how they learn and implement new pedagogy.

As a researcher, an assumption that I bring to this study is that teachers will learn and integrate new pedagogy into their practice if they think that the new pedagogy could be of benefit to them and to their students. Additionally, I believe that most teachers would modify and refine their practice if they have the tools and support to do so. Another assumption is that many teachers are interested in using technology in their teaching and that this interest in technology is an incentive to undertake the arduous and complex task of learning new pedagogy for technology integration.

This research is driven by my interests in assisting teachers' to be more effective in their practice through professional development and integration of technology into their teaching. I have worked in the education profession for 29 years in various capacities as a teacher, a college science lecturer and during the last 11 years as a Science Education Officer in the Science and Technology Section at the Ministry of Education, Youth, Sports and Culture in Nassau, The Bahamas. In the capacity of Science Education Officer, I had the responsibilities for supervision of the science program for the country. My responsibilities included curriculum development, professional development, supervision of teachers and budget management in the procurement of science supplies and equipment. I am a fourth year doctoral student in the Teacher Education and School Improvement Program at the University of Massachusetts in Amherst.

#### **4. Project Timeline**

Phase 1 of the TEFA project began in early Spring of 2006 with a series of meetings held by the university faculty that would be the facilitators of the SSSPD. All teachers in the science department of the school were invited to attend the initial meetings which were later extended to include mathematics teachers after they expressed an interest in participating in the TEFA project. The purposes of the meetings were to describe the TEFA project and the SSSPD model and to encourage the teachers to participate in the project. Baseline data collection commenced in May 2006 and continued in July and August 2006. Next, the teachers attended a three day summer workshop in August 2006 where they were exposed to TEFA pedagogy and got hands on practice with writing TEFA questions and with using PRS. At the beginning of the Fall 2006 semester, weekly sessions began that consisted of a professional development course and a once a month collaborative action research session, except on school holidays. During the second year of the project, monthly action research sessions began in September 2007 and were held up to the end of the Spring semester.

#### **5. Data Collection**

The issues of “truth value” and “rigor”(Rossman & Rallis, 2003) were addressed by gathering data over the course of two years from a variety of sources. Numerous data sources were used for triangulation and to establish trustworthiness, limit the bias of the researcher and to enhance credibility and believability (Rossman & Rallis, 2003). There were seven data sources used in this study which consisted of three sets of interviews, video taped classroom observations, action research group transcripts, journal entries and monthly reflection surveys. The seven data sources were:

1. TEFA Philosophy and Perspectives Interviews (TPPI)
2. Teacher Lesson Planning Interview (TLPI)
3. TEFA Teacher Video-Based Interview (TVBI)
4. TEFA Classroom Observation Protocol (TCOP)
5. Action Research Group (AR)
6. Teacher Monthly Reflection Survey (TMR)
7. Participant's Journal

The protocols for the TEFA Philosophy and Perspectives Interview (TPPI), the Teacher Lesson Planning Interview (TLPI), the TEFA Teacher Video-based Interview (TVBI) and the TEFA Classroom Observation Protocol (TCOP) were developed by university faculty facilitating the TEFA project. The Teacher Monthly Reflection Survey (TMR) was developed by the university faculty with assistance of a research agency located on the west coast of the United States. My responsibilities as a research assistant for the TEFA project included conducting TLPI and TPPI interviews, and conducting some of the baseline TCOP. I also co-facilitated the AR sessions with one of the university faculty for the first year and the first semester of the second year of the TEFA project.

#### Interviews

The TEFA Philosophy and Perspectives Interview (TPPI), Teacher Lesson Planning Interview (TLPI) and the TEFA Video-Based Interview (TVBI) were administered. The interviews were audio taped then transcribed verbatim and then coded. The duration of the TPPI, TLPI and TVBI interviews were approximately one

hour. (See Appendix B for goals and timeline for administration of data gathering instruments).

1. **TPPI** TPPI consisted of 27 questions and follow-up questions. The goal of the TPPI was to explore the participant's philosophies and perspectives about her role and purposes as a teacher, about classroom interaction, about her students and other aspects of her practice. The TPPI was conducted first in July of 2006 to gather baseline data and again in May 2007 at the end of the first year. (See Appendix C).

2. **TLPI** The TLPI consisted of 20 questions with follow-up questions. The TLPI explored the participant's lesson planning processes and the factors that she considered when planning a lesson by examining the context of the teacher's lesson planning, the lesson goals, the lesson design, the assessment of the lesson and the plan implementation. The participant was told in advance to bring a lesson plan that she had used before and any accompanying activities and resources to discuss during the lesson planning interview. (See Appendix D).

3. **TVBI** The TEFA Teacher Video-Based Interview (TVBI) was an in-depth semi-formal interview. During the TVBI the participant was showed two five minute video clips of her TEFA use in the classroom during baseline and during the first semester of TEFA implementation. The purpose of the TVBI interview was to elicit the participant's thoughts about how her teaching was changing, and why she thought that her teaching is changing. TVBI was administered one time at the beginning of term in Spring 2007, the first year of the study. (See Appendix E).

Classroom Observation

4. **TCOP** The TEFA Classroom Observation Protocol (TCOP) was the classroom observation protocol that was used to video tape lessons. The first TCOP was done during the baseline period Spring 2006 and was followed by TCOP done during the first and second academic year. The TCOP was done in lessons in which the participant used TEFA. The video taping was done for the 85 minute duration of the lesson. The video taping of the lessons were preceded by a pre-observation interview and followed by a post-observation interview which were a part of the TCOP protocol. TCOP was administered once for the collection of baseline data, four times during the first school year and three times during the second year. The lesson observations were transcribed verbatim. (See Appendix F).

#### Action Research Group

5. **AR** Action Research Group (AR) sessions were held once a month during the first and second year. The participant used action research to reflect on what was happening in her class and what was working and what was not working as she implemented PRS into her teaching practice. In the action research sessions there was collaborative feedback as the other participants shared how they used TEFA. Action research sessions were transcribed verbatim. Data were taken from transcripts from AR sessions that were held in both years of the study.

#### Survey

6. **TMR** Teacher Monthly Reflection Survey (TMR) was a web-based questionnaire that the participant completed approximately once a month during the first and second school year. The questionnaire contained 43 multiple-choice scales, nine open-ended text responses, and the option of making additional comments. The questions asked for

self-reporting about the teacher's PRS and TEFA experiences in the preceding month. Data were used from the TMR that was administered seven times during the first year and from the six TMR surveys administered in the second year. (See Appendix G).

#### Participant's Journal

7. **Journal** The participant was asked to keep a journal for action research which also doubled as a journal for the PD course. Keeping the journal was voluntary with no stipulation placed on the number of journal entries however, it was suggested that the participant make journal entries several times a week.

Data sources of excerpts used in this dissertation will be indicated by acronyms that represent the interviews, the action research sessions, the classroom observations or the document from which they were taken. The acronyms are Teacher Lesson Planning Interview (TLPI), TEFA Philosophy and Perspective Interview (TPPI), TEFA Monthly Reflection (TMR), TEFA Classroom Observation Protocol (TCOP), TEFA Video-Based Interview (TVBI) and Action Research Group (AR). For the interviews, action research groups, the monthly reflections and the classroom observations that were conducted or administered more than once, time will be indicated by year followed by round or session. For example the Teacher Lesson Planning Interview that was conducted one time during the baseline year and two times during the first year will be referenced as TLPI y0 for the baseline year, TLPI y1r1 for the first TLPI interview conducted during year 1 of the project and TLPI y1r2 for the second interview during the first year. The third session of the Action Research Group held during the first year of the project will be referenced as AR y1s3 whereas the fourth session of the Action Research Group held during year 2 will be referenced as AR y2s4.

## **6. Data Analysis**

To ensure rigor, several systematic procedures were followed in data analysis (Yin, 2003a). According to Yin (2003a), it is important to “maintain a chain of evidence” because “the external observer must be able to follow the derivation of evidence; to trace the steps to the conclusion” (p. 105). Establishment of a chain of evidence was facilitated by the in depth analysis of the data and the documentation of the development of categories and patterns. The transcripts of the interviews: TPPI, TLPI and TVBI were read verbatim to identify and summarize the ideas that they contained. Constant-comparison analysis was done by reading the transcripts numerous times to identify emergent themes. The emergent themes were used for developing codes for the transcripts. Then open coding, and content analysis were used for the initial data analysis and to illuminate some preliminary insights and categories. The categories were further refined after more in depth exploration of existing data. Subsequent analysis was done via axial coding and selective coding to further refine the data and to identify and interpret patterns (Strauss & Corbin, 1998; Coffey & Atkinson, 1996).

Data were coded using initial theoretical frameworks and initial categories for the first cycle of analysis with more extensive analysis and further refinement in pursuant cycles. Data coding software was used to explore the validity of the data coding scheme that was developed and further refined the categories. Narrative commentary analysis was then used. To facilitate this process, data was categorized and coded inductively and themes extracted and analyzed in light of the research question (Strauss & Corbin, 1998; Coffey & Atkinson, 1996). The TCOP videos were coded,

analyzed for patterns and then reanalyzed as patterns emerged and were further developed. Quantitative analysis was done with the TMR survey and the data were examined for patterns. Potential patterns were identified and described and “pattern matching” done to link different pieces of information from various data sources that were related to a theoretical preposition (Yin, 2003a). Some data were checked for reliability by peer feedback and by member checks then adjustments made as necessary to resolve any discrepancies (Strauss & Corbin, 1998; Coffey & Atkinson, 1996; Locke, 2004). Data were examined and analyzed for linkages, relationships and interrelationships. Each finding from the data was triangulated with at least three sources of data.

#### **D. Conclusion**

Lessons learned from this single case study could add to the research literature and increase understanding of the role of SSSPD in how teachers learn TEFA and in maintaining and sustaining teachers’ use of TEFA and other technology driven pedagogies. Using one participant as an exemplar of effective integration of TEFA pedagogy could be valuable in identifying and predicting beliefs, behaviors and skills that make a teacher predisposed to successfully integrate TEFA into his or her practice. This study could be instrumental in the development of an analytical framework of individual teacher learning of TEFA and could assist in identifying indicators and predictors to pedagogy adoption and integration and processes in the change process that could be applied to future teachers learning TEFA pedagogy. The findings from the case study could also be used as a diagnostic tool to inform the developers and facilitators of the Technology Enhanced Formative Assessment (TEFA) Project and

could be instrumental in modifying and refining the SSSPD model to better meet the needs of future participants.

## **CHAPTER IV**

### **EVOLUTION OF CHANGE**

#### **A. Introduction**

In Chapter 4, I discuss findings from the data that provide insights into the research questions that guided this study. The primary question that this chapter seeks to answer is: What can be revealed about the impact of Sustained School Situated Professional Development (SSSPD) by studying teacher learning of Technology Enhanced Formative Assessment (TEFA) in a teacher who emerged as an exemplar? In response to this question, several factors will be discussed including the complexities of teaching, especially as it relates to integrating new pedagogy and the influence of the participant's beliefs and perceptions on her practice and in her adoption of new pedagogy.

This will be followed by results that provide answers for the four secondary research questions. The first secondary question is: How has the participant's practice changed over a period of two years as she integrated TEFA pedagogy into her practice? Findings that provide answers to the first secondary question will be discussed in Sections B, C and D. In Section B, the Co-Evolution of Practice and Pedagogy Model (Beatty, et al., 2008) will be examined. Section C will describe how Tracy, the teacher participating in this study, jostled with tensions and conflicts that had to be resolved before change could occur in her practice. This will give a background to the processes of state and change that Tracy underwent as she learned the new TEFA pedagogy and is

based on Beatty, et al., 2008 model. In Section D, changes that occurred in Tracy's practice over the course of the study will be discussed in light of the Co-Evolution of Practice and Pedagogy Model. This will be followed by what the data revealed in response to the next secondary question: Are there predictors that may facilitate change in the practice of this participant? If so, what are the predictors that assist the participant to integrate TEFA into her practice? Section F explores factors that facilitated the change in Tracy's practice. The third secondary question will be answered in Section H. This question is: How does the SSSPD model affect the participant's practice while implementing the TEFA pedagogy? In this section, the effect of the School Situated Sustained Professional Development model on changes in Tracy's practice will be explored. Finally, in Section J, the fourth secondary question will be answered with findings from the data. The fourth question is: How could the findings be used to develop a model of teacher change? In Section J, I will discuss three models of teacher change including the development of the Elements of Teacher Change in Adoption of Pedagogy (ETCAP) model that was a major outcome of this study. The ETCAP model will be discussed in relation to Beatty, et al., (2008) model. I will then discuss Shulman's (1986, 1987, 1990, 1992) Model of Pedagogical Reasoning and Feldman's (1999) Model of Practical Conceptual Change and compare them to the ETCAP.

Teaching is a multifaceted, very complex intellectual, creative decision-making activity in which teachers continually make choices in the classroom as they confront, assess and align pedagogical issues (Shultz, 2005; Danielson, 1996). When confronted with new pedagogy, teachers need to effectively make practical applications of

pedagogical content as they go through the many processes of planning, teaching and refining their practice (Shultz, 2005, Danielson, 1996).

Teachers' beliefs and perceptions are strong determinants of whether they adopt new teaching methods and strongly influence their classroom practices and affect how they implement new pedagogy and new innovations (Haney, et al, 2003; Levin & Wadmany 2007). Teacher's perspectives and beliefs also determine how the teacher adapts the new methodology and whether the teacher adopts new methodology in its entirety or whether there is only partial adoption (Levin & Wadmany, 2007). It is not easy for teachers to implement new teaching approaches because it requires changing teachers' paradigm and mode of operation which is a very complex process (Levin & Wadmany, 2007).

For integration of new pedagogy and innovations to be successful, they must support teachers' existing beliefs and operational structures or be instrumental in overcoming any constraints that the teachers may experience and they must also have a positive influence on changing teachers' existing beliefs (Levin & Wadmany, 2007; King, 2007). How are the beliefs and operational structure of a teacher learning and adopting new TEFA pedagogy supported and/or changed? One of the ways that this study seeks to answer this fundamental question is by examining the Co-Evolution of Practice and Pedagogy Model (Beatty, et al., 2008) of teacher change and by discussing the change process of the participant in relation to this model.

### **B. Co-Evolution of Practice and Pedagogy Model**

In order to get a better understanding of how Tracy's practice changed as espoused in the secondary research question 2, it is important to examine the Co-

Evolution of Practice and Pedagogy Model. According to Beatty, et al., (2008) in their Co-Evolution of Practice and Pedagogy Model, teachers encounter Technology Enhanced Formative Assessment (TEFA) as represented in the professional development component. Teachers individually interpret TEFA and their perceptions of TEFA may be different from those of TEFA professional developers. This difference in perceptions causes misalignment and tensions between TEFA as perceived by the teachers and the teachers' way of enacting their practice.

This dissonance and tension result in conflicts and struggles for the teacher that are tempered by rewards and satisfaction as the teacher tries to adapt different aspects of the new pedagogy. As these tensions, conflicts and struggles are resolved, there are changes in the teachers' beliefs and abilities and there is pedagogical transformation as the teachers' perception of and their expectation of the new pedagogy changes (Beatty, et al, 2008). The changes in the teachers' practice are influenced by the teachers' experience and insights and the professional development (Goldenberg & Gallimore, 1991; Gaudelli, 2002; Gusky, 1994, 2000, 2003). The change process varies from person to person. The changes may be obvious and discrete steps or transitions or may be more subtle and less pronounced with several processes conflated together in a seemingly easy adaptation of the new pedagogy. Some teachers may also experience different levels of tension some of which are easier to resolve than others. As teachers go through the co-evolution of practice and pedagogy, there could be rapid or gradual changes in their practice as they learn how to use and integrate a new pedagogy (Beatty, et al., 2008).

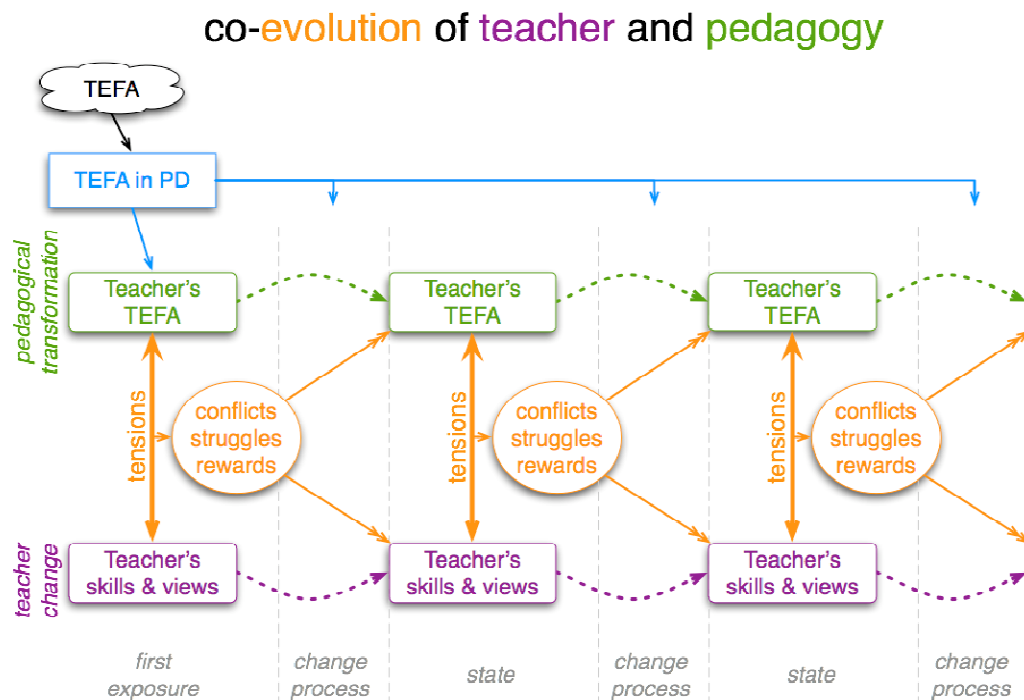
The dissonance and tensions that the teachers encounter while learning a new pedagogy are mechanisms that drive teachers' change process. While learning new pedagogy, teachers' practice evolves through a series of processes and states that are characterized by tensions, conflicts and struggles that are addressed and resolved. Primary tensions, conflicts and struggles often give way to secondary tensions, conflicts and struggles that are resolved and so on. Beatty et al., (2008) argue that evolution of teachers' practice starts with a mismatch between new pedagogy as represented in the professional development, the teachers' perception of what the adoption of the new pedagogy entails and the teachers' perspectives, abilities and outlook.

Beatty et al., (2008) also argued that teachers' practice go through a series comprised of the state of the teachers' practice at various times while learning new pedagogy that leads to change processes followed by a different state resulting in another change process. This gives way to another cycle of state and changes which is a continuous process as teachers learn and integrate new pedagogy. The Co-Evolution of Practice and Pedagogy Model in Figure 2 on the next page shows the sequence of states and change processes that lead to teacher change. In the model there are distinctive characteristics that propel change in each state of evolution of teachers' practice, and conditions that must be met before pedagogical change in the teachers' practice can occur.

### **1. TEFA Vignette**

TEFA pedagogy has four constructs that were described in Chapter 2. One of the expectations of the faculty facilitating TEFA professional development was that the lessons of teachers learning TEFA should reflect these core principles. What does the

enactment of TEFA look like in the classroom? I have included the vignette of TEFA to assist with the visualization of how TEFA is enacted in the classroom.



**Figure 2: Beatty, et al., (2008) Co-Evolution of Teacher and Pedagogy Model**

The four principles of TEFA, question-driven instruction, dialogical discourse, formative assessment, and meta-level communication support and reinforce each other and are combined in the question cycle that is the typical way that the TEFA pedagogy is enacted in the classroom. Dialogical discourse is the use of dialogue to explore what students are thinking, how they are thinking, to shape student's thinking, expand their learning and thought processes and to help them have a better understanding of what is being taught. Meta-level communication includes communication that tells students what they are going to learn, the purposes for learning, how they should approach learning and how they should think about and assess learning.

At the beginning of a question cycle, the teacher presents a question or problem to the class. Students think about it, either individually or with students talking in small groups, and decide upon their answers. The students then enter their responses into their personal response system (PRS) transmitters, which are commonly called clickers. A histogram is constructed by the PRS software that indicates how many students have chosen each answer. The teacher shares the responses with the class then moderates a whole class discussion (WCD) about the question.

Whole class discussion typically begins with the teacher asking for volunteers to explain the reasoning behind their particular choice with the initial goal to draw out the diversity of thinking behind the different answers. Prompts that the teacher may use to do this may include: “I see someone chose ‘not enough information.’ Could you tell me what else you would like to know in order to solve it?” “Several people picked answer three. Who can give me an argument why that’s a good choice?” “Did anyone have a different reason for choosing that same answer?”(Beatty, et al, 2008). The teacher manages the whole class discussion to encourage the examination and comparison of students’ ideas, development of understanding or insight and exploration of related topics. Finally, the teacher revisits key points, provides a summary, or gives a micro-lecture to end the cycle and bring closure. The teacher then transitions to another question cycle or a different activity (Beatty, et al, 2008). The excerpt below shows how Tracy implemented the four principles of TEFA in her classroom. The principles of TEFA are included in *italics*.

Excerpt from WCD during Classroom Observation (TEFA y1r2)

Tracy: Can everybody please log in because we are going to answer a general question about this reaction before we put things together?

Tracy: Okay. So, which one am I adding the ten milliliters of water to?

Multiple Students: The first one.

Tracy: The first one. So, I'm going to add ten in here [pause]. Which one am I adding the fifteen to?

Multiple Students: Four.

Tracy: Four. Before I add the Iodine to it, here is the question I want you to answer. So, everybody is logged in. Thank you. I want to know which of the combinations, so you are going to enter either 1, 2, 3 or 4 or any multiple, right? So, you do, can choose one number, you can choose all four numbers. We have done this before, right?

*Teacher presents question to the class.*

Multiple Students: Right.

Tracy: Okay. So, which of the combinations 1, 2, 3, 4 do you think will have the greatest amount of precipitate for? Okay. So, this is a double replacement. I want you to decide now. There's no--You can't get it wrong at this point you're just taking a guess of which of these you think will have the greatest. So you could enter 1, 2, 3 or all of those numbers. And I'm going to start measuring out my Iodine solution while you guys collect poll the question first. [long pause- 8 minutes]

*Teacher continues to expand on the question then tells students to select their answers. During the long pause the students discuss the question with their peers then enter their responses with PRS.*

Tracy: So, the question is which will have the greatest amount. 'And the problem's been called. But I gave you a little extra time so you can talk to each other, if you need to. Okay, so, for anybody who needed to see any of these problems, you have colleagues in the room who have used two different strategies which is nice. It is always nice to see a variety of ways to solve things, but they look great.

*The teacher encourages diversity in thinking and encourages students to discuss their strategies with each other.*

*(Joining the class later for the last question cycle)*

Tracy: So to get it back in the same place we were about a half an hour, forty-five minutes ago, we put the two solutions together but they are in different proportions and you guys took a guess as to which of the test tubes would end up having the greatest amount of sediment or precipitate on the bottom. Here are your results. [long pause while histogram is displayed and teacher and students look at responses that were chosen] A lot of people choose number two. . And two and three was chosen, and three, which means that nobody picked 4 and 1 in this class. That means anybody in this room is fair choice to explain why four is not your choice. Why is four not a good choice? Who is willing to volunteer for that? I've heard a lot from me today.

*After viewing the histogram, the teacher speaks about the answers that the students chose and starts discussion by asking students to explain their choices. She prompts the students to draw out diversity of thinking.*

Student: Because there is a big dance floor. Like you said before

Tracy: Okay, so there is a big dance floor. Alright, I like the analogy. Big dance floor.

Student 1: More room to Tango.

Student 2: Exactly.

Tracy: More room to Tango. What would a big dance floor have anything to do with making precipitate?

*Teacher continues with question driven instruction and manages discussion to develop understanding or insight.*

Student 3: There wouldn't be as many people.

Tracy: Okay there aren't as many people. Who are the people in our story?

*Teacher continues question driven instruction to probe students to examine their ideas and expand their understanding.*

Student 4: The lead and the iodine.

Tracy: Okay, so lead and iodine they are going to dance together and make a precipitate. So you have the same size dance floor, so the volume is the same, but there are not as many dancers. How do you know that? What is the numerical evidence that there are not as many dancers? I like this, this makes a certain thing.

*Teacher continues to examine students' ideas and thought processes as she formatively assesses students conceptions*

The next section examines Tracy's perceptions of some of the tensions and conflicts that she experienced while learning and integrating TEFA. The TEFA vignette above gives the context to the experiences, tensions and changes in Tracy and in her practice while she integrated TEFA.

### **C. Jostling Tensions, Conflicts and Struggles**

In section C the focus changes to Tracy, the participant of this study. In the sections C and D, there will be in depth discussion about many aspects of Tracy's practice – the tensions she experienced, what she did, what she learned, how she changed, how her teaching changed and the benefits she accrued from learning and integrating the new TEFA pedagogy. I will use many quotes from the seven data

sources analyzed for this study because I feel that it is important to show Tracy's beliefs and perspectives of how she learned and experienced TEFA and share her thoughts about her tensions and triumphs as she integrated TEFA.

Section C highlights some of the tensions, conflicts and struggles that Tracy experienced while learning to integrate TEFA. According to Beatty, et al (2008) in the Co-Evolution of Practice and Pedagogy Model when learning new pedagogy, teachers' experience tensions, conflicts and struggles because of misalignment of their perceptions of new pedagogy as presented to them and their way of enacting their practice. As these tensions are resolved, they may give way to new tensions. As Tracy was trying to integrate TEFA into her practice, she encountered tensions, conflicts and struggles that had to be confronted and resolved before there could be change in what she did in the classroom.

When talking about tensions that she was experiencing as she was trying to integrate TEFA into her practice, Tracy often used delineative words like "struggling", "grappling", "wrestling", "fighting", "tug-of war" and "difficulties". The following statements that Tracy made near the end of the first semester of the project indicated that she was struggling with trying to understand why she was not using TEFA more even though she acknowledged that it was beneficial to her students. Tracy spoke about rationalizing why she was not using TEFA more often as indicated in the statement below.

I kind of **wrestle** with -- I'm trying to rationalize in my mind why is it that I don't choose this (*PRS*) more often. It could also be that I'm just lazy. Who knows? I don't think so" (TLPI y1r1).

Another thing that Tracy was wrestling with was her students being the advocates she encouraged them to be and them telling her what they needed from her to learn. Tracy's students' request was in conflict with what TEFA pedagogy was advocating. The excerpt below explains this tension.

I've had a cluster of students, good students, say, "We don't like it when you teach us that way. We want you to say 'this is it,' instead of 'if you believe this and if you believe this, then can you make this next jump independently?'" And I'm **wrestling** with what to do with first of all their courage to say, "Please don't teach us that way." That's great for them to be that proactive" (TLPI y1r1).

The change Tracy was trying to make in her practice of not telling her students the right answers when they experienced challenges (as encouraged in the TEFA PD course) was causing dissonance.

Tracy described the tension that she was experiencing with striving for depth of understanding in her students rather than covering the breadth of the curriculum as a "**tug-of-war**" (TLPI y1r1). Tracy was concerned about the time needed to integrate TEFA and her belief that she had to keep a rigorous pace to cover the curriculum. In the TMR y1r4 survey in January of the first academic year, Tracy's response to the question, "Day-to-day, what aspect(s) of using PRS + TEFA have you been most focused on or concerned about during the last month? That is, which most demand your attention? Tracy described the tension she was experiencing as, "**Fighting** a sense of needing to cut discussion time short" (TMR y1r4).

During the TVBI interview in February of the same year, Tracy stated that "I've **fought** and **fought** with Bill Leonard (faculty facilitating the PD course) about closure in September" (TVBI y1r1). She was explaining her early "frustration" at not telling students the answer to questions which was what she felt she needed to do to bring

closure. She was “fighting” with Bill because not telling students the answers was being encouraged in the PD course and this was stylistically opposed to Tracy’s way of teaching.

Another tension that Tracy was grappling with was her belief that she needed to be in control. Tracy exhibited a determination to be in control and referred to herself captain of the ship and as queen in the TLPI and TPPI interviews. In using the analogy “captain of the ship”, Tracy referred to many aspects of her practice in terms that reflected her role as captain of the ship. The quotes below were chosen to highlight what has emerged as one of the most dominant traits of Tracy’s personality, which was entrenched in her belief system and influenced her practice during the two years of this study. During the baseline TEFA Philosophy and Perspectives Interview (TPPI y0) when describing her roles and responsibilities and later in the same interview when speaking about one of her expectations of the TEFA project Tracy stated,

I'm going to be the one who kind of steers the ship...you can be with me on the ship, but that's one of my big goals is to make sure that we're moving forward and that we're keeping a rigorous pace.... I'm thinking of my AP Chemistry class, that's where, I think, some people start to fall off the boat and then they don't tell me until a week or so. And we're keeping the pace, and I think, "oh wow," you really don't know how to find the square root of this thing...so, and yeah, I'm hopeful that the technology we're going to learn about gives me a sense of when to offer the assistance, especially since sometimes kids are reluctant to ask for it (TPPI y0).

During the baseline Teacher Lesson Planning Interview (TLPI y0) while discussing her lesson on the mole concept Tracy said, “I am a control freak, so for this unit, for this lesson I should say I have overheads”. Tracy would use the transparencies to give students the steps to determine the empirical formula for doing mole problems if she felt that they were “eating up too much time” in trying to figure out the formula

(TLPI y0). In TPPI y1r1 she said, “I sort of see teaching in a way as sort of keeping the hoop going, but making sure it doesn’t get away from you.” Her determination to always be in control was resistant to change for the duration of this study, however she relinquished some control as the project progressed.

While learning and integrating TEFA, Tracy encountered different challenges that she jostled with and seemingly easily and quickly resolved with very little effort when compared to the other nine teachers in the study. Careful scrutiny of the data revealed that although Tracy quickly adapted TEFA to fit her practice, there were a number of processes that she went through before adapting TEFA and changing her practice. Some of these processes were conflated giving the appearance of just one process, however these processes were comprised of a number of diminutive tensions. The changes in Tracy’s practice were not discrete steps or transitions but rather a number of primary tensions that were quickly resolved, and gave way to secondary tensions in some cases that she continued to struggle with. When faced with tensions, Tracy made an initial adaptation of TEFA followed by more gradual changes. As Tracy’s refinement of TEFA continued, her use of TEFA came closer to the ideal model of TEFA as represented in the PD. Tracy quickly found adaptations of TEFA that were regarded as high quality by project staff. Section D will deal with changes that occurred in the evolution of Tracy’s practice.

#### **D. Changes in Tracy’s Practice**

This section crystallizes the numerous changes in Tracy’s practice during the two year purview of this study and seeks to answer the secondary research question, How has the participant’s practice changed over a period of two years as she integrated

TEFA pedagogy into her practice? While learning TEFA pedagogy and trying to integrate it into her teaching, many changes occurred in Tracy's practice. Feldman and Capobianco (2007) constructed a model of four categories of knowledge skills that were necessary for teachers to integrate technology enhanced formative assessment (TEFA) into their practice. These skills areas were: 1) software and hardware, 2) item construction, 3) pedagogical methods, and 4) curriculum integration. Tracy's learning of TEFA could be categorized using the same skill areas as the learning of the teachers in the Feldman and Capobianco (2007) study, therefore Section D is arranged using their model.

The changes that occurred in Tracy's practice during the two year purview of this study, are examined using the Beatty, et al., (2008) Co-evolution of Practice and Pedagogy Model that was discussed on pages 108 – 111 of this chapter. The premise on which Beatty, et al model is grounded is that teachers undergo several cyclic processes of states and changes during the evolution of their practice. These cycles of states and changes are characterized by dissonance, tensions and conflicts that have to be resolved before change could occur in the teachers' practice. Tensions and conflicts that Tracy encountered as she learned and tried TEFA pedagogy will be described followed by what the data showed about how the conflicts were resolved. The changes that Tracy made in her practice after the tensions were resolved will be highlighted. Changes that occurred in Tracy's beliefs and in her skills will also be explored.

Confidence with the hardware and software was not an issue with Tracy because she came into the TEFA project with what she described as a "level of confidence with technology" (TPPI y0). Although Tracy had no problems with the hardware and

software, she experienced various tensions, conflicts and struggles with the other skill areas of Feldman and Capobianco model (2007). These tensions and conflicts had to be confronted and resolved before change could occur in Tracy's practice. The main changes that occurred in Tracy's practice as she learned TEFA were in: 1) question construction; 2) pedagogical methods with focus on facilitating productive dialogical discourse inclusive of closure and summarizing her lessons, managing whole class discussion (WCD), student participation in WCD; and 3) curriculum integration, which includes depth verses breadth in covering the curriculum, fitting TEFA into her style of teaching and finding places in her curriculum to integrate TEFA.

Change is a very complex and often difficult process. Tracy acknowledged this when she stated,

I think we all – teachers, and parents sometimes-we know the answer we want, let's get there and move on, you know. And reflecting on what the learning part really is, it's the trying to justify why I should bother changing what I already believe, which is the time-consuming part, but I think the useful part (TVBI y1r1).

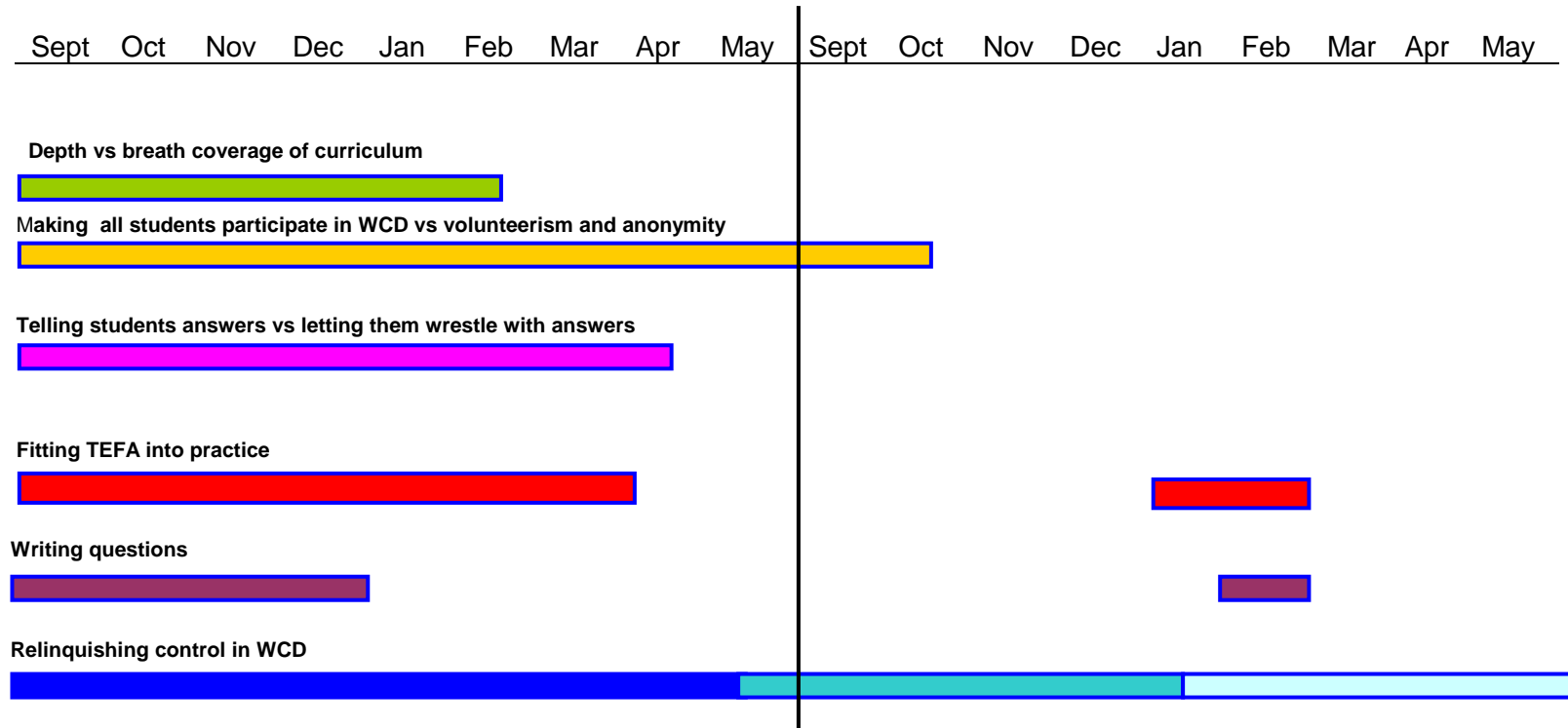
In the quote above, Tracy addresses some of the complexities teachers face when learning to integrate new pedagogy. When people have been teaching a certain way for a long time, their way of doing things is ingrained in their practice and becomes an integral part of their sense of self (Feldman, 2002). Persons usually feel that it is more expedient to do things the way they have always done them and Tracy was no exception. After forming her initial perceptions of the TEFA pedagogy, Tracy began the arduous task of evaluating and confronting her way of doing things. This meant that Tracy had to acknowledge that the practice that she had worked years to build up was flawed or deficient in some way. This is often a very difficult and time consuming process that

involves a lot of reflection and self analysis followed by justification of why she should change. The new pedagogy has to be instrumental in achieving the goals of the teacher before the teacher is receptive to its integration. This process of a teacher confronting her way of teaching, admitting her deficiencies and reconciling the new pedagogy with her way of being is reflective of Feldman's (1999) practical conceptual change theory.

This section highlights changes in Tracy's beliefs, in her skills and in her practice resulting from her use of TEFA and PRS. There was gradual and steady evolution of Tracy's practice while learning and integrating TEFA and PRS. The evolution in Tracy's practice was characterized by her trying small parts of TEFA as she dissected TEFA into manageable chunks and personalized TEFA with subsequent steps. As tensions with the pedagogy integration were resolved, Tracy continued modifying TEFA and trying other parts of the pedagogy. This does not mean that she only worked on one part or component of TEFA at a time, but rather sometimes she implemented several components of TEFA simultaneously. During the purview of this study, some components of TEFA pedagogy that Tracy was working with were more at the forefront than others. Some of Tracy's tensions were resolved quicker than others. (See Figure 3 Timeline of Duration of Tracy's Tension on the next page). The Timeline showing Tracy's tensions will be referred to throughout this chapter. The Timeline of Duration of Tracy's Tension was developed from the seven data sources by marking when Tracy mentioned challenges that she was experiencing in the various data sources and was also based on what was observed in her classroom. These challenges were then mapped in a timeline based on when the interviews, classroom observations and action research sessions were conducted and the TMR monthly surveys administered. The challenges

2006

2007



Data sources: TPPI, TLPI, TVBI, TMR, TCOP, AR, Journal

**NB** Lighter color in the same bar denotes that the tension was becoming less intense. The intensity was measured using statements that Tracy made in the data sources where her statements indicated that she was feeling less tension with relinquishing control as the study progressed. This decrease was also supported in the lesson observations.

**Figure 3: Timeline of Duration of Tracy's Tensions**

that Tracy mentioned during AR sessions and in her journal on specific dates were also used to map the timeline. (See Appendix B for administration times for the data sources).

Initially, I am using an excerpt from the TEFA Video-Based Interview (TVBI) conducted in February of the second semester of the first year to point out changes that Tracy identified herself as changes to her practice. The self-identified changes included changes in the pedagogical methods that Tracy used and indicate the success that she was having with curriculum integration of TEFA. The changes are then supported by findings from other sources.

#### Excerpt from TEFA Video Based Interview (TVBI y1r1)

Researcher: Okay, well, we're certainly moving into my second question, which is how- whether you can, whether you could attribute the changes you're talking about to TEFA and what ways.

Tracy: Yeah, from my perspective, not in terms of facilitating conversation, but from my perspective, I feel like I've been more, contiguous in, in terms of using the conversation of one day as the jumping off point or the planning point for the next day. Because...and I guess the jargon would be, I've pre-assessed as a result of conversations that students have had with each other in discussion in the class.

I've changed the pace of classes. So I've either slowed down or I've gone off on a little, like mini-lesson on the side...I have a group of students who, as of last Wednesday, told me that they believed that, if you add the same amount of heat energy to cold water, versus, the same amount of energy to warm water, the cold water will go up more, temperature-wise than the warmer water will. So, we wrote a hypothesis, and then I went home and I said, "Wait a minute, they need to actually do this."

So we did a little mini-lab. They wrote up what they thought the hypothesis was and then I discovered that they're really sloppy, in terms of what they controlled. They used different types of metals. They didn't know the mass of the metal that they used. There were so many things that we actually ended up talking about that...same time last year, same unit, I would be cruising on to Hess's Law, and feeling good about it as a decision – (I'm) as a teacher-saying, wait a minute, if they believe this, we can't go on to Hess's Law.

So, I like that as information for me to meet them and say, "Well, if you believe this, I have to persuade you, or have, set it up so that you come to the conclusion--see that would be the real art. That would be the best part. For me to be able to ask the question that says, "Whoa, it didn't matter." You know what I mean? And...they're not there yet. I'm trying to drag them to that point without telling them, and that's the hard part.

Researcher: So, that goal that you have, that you just stated...did you have that goal last year?

Tracy: Yes. That's always been something I've wanted and I think that's why I've warmed up to TEFA so quickly. Because, in an ideal world, we'd all be apprenticed to someone who was our perfect teacher. You know what I mean? Who could, who would say, "Oh, you know, this is something, regardless of whether it's on my curriculum or not, I see that you don't understand." We'll take the time, and we'll straighten this part out, because it's relevant to now, instead of relevant to this...curriculum. And, yeah, it's our job to set up a curriculum and to follow a certain skeletal pathway, but really, if your students aren't ready to be there with you, it's pointless. And I've been doing it too long and feeling pointless sometimes...

So, at that point, I decided, that evening, forget moving on to, you know, practicing math equations. We're going to do a lab and, we would have done a lab anyway, but it would have been more directed by what I usually do, instead of saying, "Okay, here's some material. Here's our hypothesis. Good luck!", and safety wise, not good luck, but do with it what you feel you would need to.

This excerpt from the TVBI interview done in Spring of the first year documents Tracy's self-identified changes in her practice. The changes that Tracy identified in her practice included: 1) using pre-assessment and formative assessment to guide future lessons; 2) changing the pacing in classes based on formative assessment; 3) having a better understanding of students misconceptions and understanding of concepts; 4) using less directed labs to elicit student thinking and build their problem solving skills; and 5) the change in Tracy's belief about the need to cover the curriculum to her being more flexible with addressing the students' needs for relevancy and more depth in understanding. The excerpt also shows that Tracy's paradigm was changing with changes in her thinking and beliefs. She was rethinking her belief that she had to keep a steady pace and was more willing to spend more time on topics, put in additional activities to supplement what she was doing and make her labs more student directed.

### **1. Question Construction**

TEFA requires time to write effective questions and Tracy was experiencing tension because she struggled with the amount of time needed to write questions, which was critical for the effective implementation of the TEFA pedagogy. This tension was

resolved as Tracy became more skilled in writing questions. Tracy's skill of writing questions was at a high level, which was reflected in the new type of question that she created that was not modeled in the PD course.

**a. Lack of Time to Develop Questions**

Tracy needed more time to develop questions that she considered consistent with her goals and beliefs because she had started to think about question writing from a different perspective than the way she approached question development before her participation in TEFA. These changes in Tracy's perspective and in her thought process when writing questions were factors that influenced the amount of time needed to write questions. Tracy was now putting herself in the students place and thought of questions the way that she thought her students would interpret them and possible answers that they may come up with. She also thought retrospectively on the misconceptions she had when she was a student when developing questions for her class. This more in depth, analytical way of thinking about and developing questions was a change in Tracy's practice that she attributed to TEFA. Tracy's new way of thinking is supported in the following excerpts from the TVBI interview and the TLPI y1r2 interview;

Researcher: So what about what you're doing using TEFA is different from how you taught last year?

Tracy: I didn't spend any time trying to think of what answers students might come up with. In order to write the question, you kind of have to switch perspectives. So what makes it difficult and time-consuming to write the questions and have them be really useful. It is sort of to try to get your brain back to the point where the content was new to you and there are things that you believe to be true about electrons or heat transfer or equilibrium that may not be true or accepted by the general scientific community. So I think that's been a really good thing to say, okay, if I were looking at this for the first time, or if I can think back to when I looked at it for the first time, what were the things that I found annoying, bothersome? And then incorporate them in a statement that sounds really good and believable, and then have them ultimately 'fess up to why they, why they think it's true (TVBI y1r1).

In the previous excerpt, Tracy spoke about her new approach of trying to think the way students think to design questions that challenged them as one of the reasons that writing questions was “difficult and time consuming”. In April of the first year, Tracy was still experiencing tension with the amount of time it took to write questions.

Just typing these (*PRS questions*) out I knew, because it took me so long to come up with the ideas that I had put little kind of like catches in a couple of them that we would have had to have slowed down and said, "Well wait a minute. We never tested for, therefore you have to back track" (TLPI y1r2).

#### **b. Question Style**

In several data sources, Tracy mentioned that she particularly liked a style of question modeled in the PD course that she called the “Oops! go back” question (TLPI y1r2) which she also referred to as “Wait, wait, go back” in the statement below.

There's a strategy that Bill Leonard was asking us to try called, I call it "wait, wait, go back." So you present a question, and then you present one that's similar, but not quite the same. And then another one that leads you. hopefully, back to the first, that says, "Nope. I want to change that" (TVBI y1r1)

Tracy showed innovation in developing a new type of question that was not modeled in the PD course and that went beyond the types of questions that were discussed in PD. Tracy explained, “I like it better when it's multiple options for answers as opposed to, here are these multiple choice questions” (TVBI y1r1). This is consistent with Tracy’s belief in TPPI y0 that, “some of the most interesting class discussion we've had have not been with people who all were in general agreement” (TPPI y0). This belief is also underscored in the excerpt below.

I like it better when it's multiple options for answers as opposed to, here are these multiple choice questions. 'Cause I have used it with my AP Chemistry class to go over a practice, um, exam, where you have five choices, they're

lettered choices, there's only one right answer. It gets monotonous. But it's also useful too, because it kind of lets you know that at least they were engaged enough to push the button... So you pose a question and you give them some possible choices, and I like the idea of saying 'none of the above,' 'all of the above,' that kind of thing more--I like learning about 'none of the above,' because it sort of throws a little monkey wrench in there and they say "Well, wait a minute, maybe none of these things are true." So, and that's more true to real life too. I mean, maybe you've got all these ideas that really...none of them apply. So, when I have been trying to write questions, I want to have more than one right answer. It could be several answers that you think are acceptable (TVBI y1r1).

Tracy believed that multiple choice questions could not adequately challenge students to stand up for and defend their choice of answers. Tracy's creation of a new type of question was consistent with her beliefs that there should always be more than one correct answer because in the world context there is always more than one correct solution. This type of question was also consistent with her belief that science invites challenge as indicated in the following statement;

by nature of being scientific knowledge it needs to request or imply that you ought to challenge it. And that's something that I've tried and been a little more successful with while using TEFA. Actually having kids tell me "I don't believe you" is really good (TPPI y1r1).

Tracy believed that students should be committed enough to what they believe not only to stand up for it, but also to justify their beliefs and to try and convince others why their response was the right one. This is consistent with Tracy's belief that her students should be proactive learners who were advocates.

Tracy felt that the new type of question was effective in eliciting students' thinking and in her words, effective at "generating challenge to what kids understand" (input from PD course, TPPI y1r1). During the second year of the study, Tracy continued to use this elaborate type of question that involved high levels of logical

reasoning as revealed in her second and third lessons that were video taped in year two of the study (TCOP y2r2, y2r3). Although the video taped lessons showed that Tracy had developed proficiency in writing questions, Tracy still wrestled with what she termed “writing useful discussion questions” and “discussion style questions” up to February in the Spring semester of the second year of the project (TMR y2r2, y2r3, y2r5). (See timeline of Tracy’s tensions on page 122).

**c. Summary**

The tension Tracy experienced with how much time it took to do TEFA decreased as her skill of writing questions developed resulting in less time required for her to write questions. Tracy approached question writing differently than the way she did previously. Tracy had success with using a new type of question that she created and liked the way it elicited students’ thinking. This new style of question was considered high quality by the faculty facilitating TEFA PD. Even though Tracy experienced success in question writing, the data showed that in the Spring semester of the second year of the study, she said that she was having difficulty writing questions.

In the previous part of Section D on changes in Tracy’s practice, I discussed tensions that Tracy experienced with the time it took to write effective questions. Tracy’s new approach to question writing and her thoughts about different styles of questions taught in the PD were also discussed. Finally, Tracy’s innovation in creating a new type of question was explored.

In the next part of Section D, I will discuss pedagogical methods that Tracy used based on findings from the data. These findings include tensions that Tracy were experiencing with bringing closure and summarizing her lessons, with whole class

discussion (WCD) and with her students' participation in WCD. I will give examples of how she resolved these tensions and describe changes in Tracy's practice as the tensions were resolved. Next, I will discuss Tracy's development as a scribe and her thoughts about TEFA and PRS usage.

## **2. Pedagogical Methods**

In this section, tensions that Tracy experienced with different aspects of whole class discussion and the changes that Tracy experienced after the tensions were resolved will be discussed. These tensions and the resultant changes that occurred after the tensions were resolved are in regard to Tracy bringing closure and summarizing her lessons, managing whole class discussion (WCD) and student participation in WCD.

### **Closure and Summarizing**

Tracy was experiencing tension because TEFA encourages teachers to bring closure to their lessons, however Tracy's self-identified weakness of not bringing closure to her lessons led her to implement TEFA without closure. Tracy changed her practice by structuring her lesson to bring closure by the end of the first year.

Additionally, TEFA encourages teachers to maintain neutrality and let students struggle to figure out answers but Tracy had a tendency of telling students the correct answer if she felt that they took too long to respond. This caused tension and posed some challenges for Tracy.

### **a. Summarizing Lessons**

Two aspects of summarizing are dealt with in this section. Tracy used the word summarizing to describe revisiting key points that students should have gotten from class discussion or from a particular lesson activity. Tracy also referred to this aspect of

summarizing as bringing closure and interpreted this type of closure as telling students the key concepts that they were supposed to learn. Another way that Tracy thought of summarizing was to review and underscore points at the end of the lesson. Tracy identified summarizing her lessons as an area that needed improvement and frequently mentioned it in interviews and in PD sessions and she hoped “that TEFA would help her improve” (TPPI y0r1) in this area. “I think I mentioned in previous interviews that one of my weaker spots is the summarizing aspect of being a good teacher” (TPPI y1r1). Tracy blamed her over planning (even though she had block periods of eighty-five minutes) for her not being able to summarize her lessons. Tracy explained that this was another reason why she spent so much time grading and commenting on the homework. In the baseline data she stated,

I very, very frequently never get within one lesson to the summarizing portion to the lesson which is, if you read my plans for improvement down in the office, you know how we go through five year cycles. That's where I have to manage things better because for some kids I never get to that summarizing piece so that makes the review the next day all the more important. So I say, "Okay, where were we yesterday when the bell rang and I didn't say the summarizing piece. Oh, today we've learned this, this and this because my mouth is open and the bell is ringing...So there's a cyclic loop here that says I know that I over planned...In terms of my personal growth, I'm not good at all in terms of summarizing and say, "Okay, you were here and look where you are!" I never get to that point.

**b. Telling Students the Answers**

Tracy was experiencing tension in not giving students the answers and key points especially when students were taking too long to arrive at them as she was accustomed to doing before her participation in the TEFA project. In the next statement, Tracy referred to the tension she was experiencing with not telling students the answer.

But philosophically, I kind of like the 'I'm not going to tell you what it is' philosophy that Bill Leonard is sort of pushing and I need to sort of make that fit with my style and my students' comfort level...then I broke the rules by telling them "These are the ones you should've picked." (TLPI y1r1).

The tension resulted from TEFA as it was presented in the PD course with the facilitators encouraging teachers to allow students to wrestle with concepts to elicit their thinking and Tracy's students' frustration at not being told the answers to problems if they were stumped. The students were demanding that she tell them what she wanted them to know. This was still a tension at the end of Fall in the first year (TLPI, TPPI, AR sessions, Journal 12/4/06) as reflected in this statement,

I had kids beg me for that (*closure*) actually. They said, "we hate this because you never tell us what the answer is supposed to be....But what were we supposed to get out of it, why did we do it in the first place?" ...Summarize the good ideas that students had and maybe the good ideas we should investigate next time, but what was the point here and that's what they said, they said, "we don't want to do this because you don't tell us." and really what I heard is, "You don't tell us **why** we did this" (AR y1s4 12/18/08).

In the AR session and the TVBI interview done in February of the first year, Tracy spoke about "trying to be neutral" (TVBI y1r1) and making a conscious effort to not tell students the answers. Tracy described the tension that she was experiencing with not telling students the answers in the statement below.

However, there's a problem with letting that (*not telling students the answers*) go too long, and kids were screaming for closure, after a day and a half of that style. They said, "We want to know what you want us to know." And...I think that that's fair (TVBI y1r1).

In the preceding statement, Tracy's students being unhappy with her new style of teaching – not telling them the answers was one of the main reasons that she was experiencing tension. Her students were demanding that they be told the answers.

Although Tracy continued to improve in this area throughout the first year, she

admitted that she often fell back into her old habit of telling students the answers in various data sources. By the end of the first year, Tracy was incorporating pro TEFA strategies like giving students more time to think and not giving them the answers into her practice more frequently. This tension that Tracy was experiencing by being pressured by her students to tell them the answers is corroborated in the following statements.

I have found that I'd come back because they've said, "please tell us, which ones would you have picked?" and yeah, I have told them. Good choice and why, but it's the timing of when to do that right now for me (AR y1s5).

I told them, "Don't beg me for the answers the first time out when we use this, because I'm going to try really, really hard not to tell you. But I promise you that, at some point, we are going to make a statement that says, "This is the nugget that you really need" (TVBI y1r1).

In April of the first year Tracy was experimenting with "sort of holding back more" (TLPI y1r2) and there was a noted improvement in this area. She mentioned that she "absolutely refused to say, "Okay that's the right answer". They were livid. They were so upset" (TLPI y1r2), but in the same interview Tracy acknowledged that she was still wrestling with this conflict but her beliefs and teaching style were changing because of what was being taught in the PD.

I'm wrestling with what to do with first of all their courage to say, "Please don't teach us that way." That's great for them to be that proactive. But philosophically, I kind of like the 'I'm not going to tell you what it is' philosophy that Bill Leonard is sort of pushing (TLPI y1r2).

Tracy explained that not telling students the answers was difficult and that the reason she was having problems with it was,

part of my teaching style, is that I really need to fill the air with my own voice and that's not always so good. It's a reflex. It's an old fear of if it's quiet what are we doing? And they have that fear, too, because when I stop talking they --

they're looking at each other like, "Okay, so what are we doing now?" (TLPI y1r2)

In the following excerpt, Tracy explained her frustration and the conflict that she was having because she was being encouraged in the PD course not to be too quick in telling students the answer.

I think TEFA keeps me from wanting to reach closure. And I've fought and fought with Bill Leonard about closure in September. I didn't fight with him, but I was frustrated and my students experienced frustration and spoke to me about it too, with when is the time to tip your hand. You know what I mean? And it's made me reconsider...whether subconsciously, I've been doing most of the...drawing most of the conclusions, instead of letting there be more time for kids to try to get to the point (TVBI y1r1).

Tracy may have been thinking of her tendency to draw students to her conclusion instead of allowing them to think and come to their own conclusions when she made the following statement in baseline data;

I know that sometimes I've pushed ahead with material when I, perhaps, shouldn't have knowing that I have this certain agenda, and it's my agenda not theirs, which ethically, as a teacher I don't know how I feel about it, but I do it (TPPI y0).

In the first year, the resolution of Tracy's initial tension of telling students the correct answer led to a secondary tension when her students' asked her to tell them the answers "because I hear those kids loud and clear. I want you to tell me what am I taking away from this" (TLPI y1r1). This resulted in Tracy being caught between something she valued TEFA for and what her students expected from her (TMR, TLPI y1r1, TPPI y1). In trying to resolve this tension, Tracy ended her lessons by telling students the answers. This tension of the need to bring closure and to summarize key points at the end of her lesson was resolved in Spring of the first year. Tracy's progress in this area is noted in the two excerpts below.

I ultimately, at the end, summarized it and said, "Of these six statements there are only two of them that are false. The rest are true" (TLPI y1r1).

Excerpt from Action Research Session (AR y1s4)

Tracy: I had kids beg me for that (*closure*) actually. They said, "we hate this because you never tell us what the answer is supposed to be."

Researcher: But I'm not saying the answer.

Tracy: 'But what were we supposed to get out of it, why did we do it in the first place?' And summarize the good ideas that students had and maybe the good ideas we should investigate next time, but what was the point here and that's what they said, they said, "we don't want to do this because you don't tell us." and really what I heard is, "You don't tell us *why* we did this."

This change in bringing closure to her lessons that Tracy spoke about in the PD and in interviews was supported in the TEFA Classroom Observation Protocol (TCOP) done in the second semester of the study in which two of her lessons were videotaped. This is reflected in the statement below.

You know what we will do, we'll leave it there (*on the board*) overnight and I'd like to do a little bit of summarizing because we are going to run out of time. And one of the frustrations that people have expressed with PRS is that it's great to vote but if you don't know what the intent was its kind of hard to enjoy it. I would pick three, so those of you who were swayed to three as a choice you are at least voting with me and we will see tomorrow whether or not we are correct or not. Because it should work out I hope that three is the one that is going to have the largest amount of precipitate (TCOP y1r1, 12.06.2006).

Tracy ended the lesson by telling the students what her choice of answer was as a way of letting them know what they should have gotten from the discussion. She set the stage for discussion of the answers the following day and for them to challenge whether option three was correct. This is reflective of her belief that science invites challenge.

**c. Summary**

Tracy changed her style of teaching and the format of her lesson by adding summaries to establish truth as a means of resolving this tension. Tracy's practice evolved from not summarizing at the end of her lessons to summarizing key points to

pointing out some possible solutions to set the stage for further inquiry in the next day lesson. Although it was a struggle for Tracy not to tell students the answers so that they would have more time to think and think more deeply, this tension was resolved gradually and by the end of the first year there was a definite change in what Tracy did in her class and in the pedagogical methods that she used.

### **3. Whole Class Discussion (WCD)**

Tracy had to resolve two main tensions in regards to WCD. These tensions were feeling uncomfortable with the amount of time needed for effective WCD when using TEFA and PRS and with the control that she thought she needed when managing WCD. TEFA promotes student-driven dialogue, which conflicted with Tracy's strong need to exert control resulting in students cycling questions through her.

Tracy believed that through effective WCD she could use formative assessment for insights about when to re-teach and when to move on and could facilitate students becoming better learners who were proactive. Although Tracy realized these benefits of TEFA early in the study, she believed that time was limited, which was problematic for her. However, her tension with the time it took for WCD that promoted formative assessment lessened as Tracy's goals and expectations to better address students' needs were realized. Tracy wanted her students to be engaged, proactive learners and she was willing to try and make the adjustments necessary to integrate the WCD component of TEFA.

Tracy was influenced by her learning style of making incremental steady steps in trying different ways to make WCD more effective. Tracy experimented with different ways of relinquishing control during discussion, with the level of students' volunteerism

and anonymity that she was comfortable with during WCD and with using WCD for different purposes. She was “fighting a sense to cut discussion time short” (TMR, y1r4), questioning whether she should continue making all students respond and was very cognizant of how the students reacted to what she was doing and paid attention to their verbal feedback.

In the baseline, Tracy felt that using student-centered strategies like discussion kept her “alert”. She further indicated that she liked this method of teaching, but had some concerns about using student-centered approaches because sometimes “I am not exactly sure whether it is right first of all and if it would be a better way to teach or learn” (TLPI y0). Tracy also had misgivings because she believed that this approach “eats up too much time” (TLPI y0). By the end of the first year, Tracy’s tension with the amount of time needed for discussion was resolved when she realized how important effective discussion was for eliciting students’ thinking as indicated below;

*The whole class discussion piece of it, I plan to keep using. It's convinced me that it's worth the time more often than not, because in a funny way I've had to double back because I didn't know that kids have misconceptions, or people did poorly and I didn't know why. I think it was because I never asked. You know what I mean? I never really gave them a chance to say "Well, yeah, I think that, you know, electrons are like this" ... It's convinced me that it's worth the time...writing questions with the intention of generating some sort..."challenge" to what kids understand...I like that about TEFA” (TPPI y1r1).*

Who Tracy was as a teacher and what she did in her classroom had a direct impact on how she used and managed WCD. Tracy had a strong frontal orientation and described herself as “a control freak”, which had an impact on her relinquishing control during WCD. A teacher with a strong frontal orientation predominantly conducts her class from the front of the room. Tracy managed discussion by having students channel

their answers through her. Her perception of the TEFA pedagogy was that it had rules. When talking about not giving her students the answer Tracy said, “then I broke the rules by telling them “These are the ones you should've picked.” (TLPI y1r1). Tracy also believed that for TEFA to be effective there should not be frontal teaching. “How I’m interpreting this pedagogy is supposed to work, is that the teacher is really not supposed to be the front” (TLPI y1r1). Five months later, Tracy said, “I’m trying really hard not to be, at least for my experiment for this quarter, not to be the front” (TLPI y1r2).

**a. Experimenting with Relinquishing Control**

Although Tracy was making some progress in this area, it was very difficult for Tracy to relinquish control in discussion and her need to have control seemed to be the belief that was most resistant to change, which is reflected in the following statement.

The sub target was, instead of me leading the discussion which I’m trying to get away from, but I don’t think it’s realistic to expect that I’m going to step out entirely (TLPI y1r1).

Tracy referred to the tension she was experiencing with relinquishing control during WCD in several data sets. Tracy explained her role in managing discussion as, “I’m the initiator, I’m the one that starts the question... more and more students are talking with students, but it still cycles through me” (TPPI y1r1).

Tracy experimented with different ways to relinquish control and have students have a more proactive role in discussion. She “pulled their numbers randomly out of a bag and I said I want you to stand at the board, two of you at a time” (TPPI y1r1). Tracy also experimented with various small group configurations and tasks that encouraged students to debate justify and defend their responses and convince others that they were correct. She also encouraged students to come to the board and lead the class as they

outlined their problem solving strategies. During the third videotaped lesson in year 1, Tracy chose two students and asked them to run the class, which they did, modeling the way she called on each student to respond (TCOP y1 r3). Tracy shared one of her strategies for encouraging more student directed WCD in the following excerpt from one of the action research sessions.

I got videotaped. It was fun. Actually I planned an activity where I actually had my students using, they weren't actually using the computer but they collected the histograms, so they asked the questions and the histogram was part of what they had to use to lead the conversation (AR 3/26/08 y2s6).

As Tracy reflected on her practice with the aid of discussions in the PD course and through looking at her video taped lessons, she got a stronger awareness that her WCD were predominantly teacher directed. Tracy was trying very hard to change her frontal mode of teaching because the PD course was emphasizing more student directed WCD with more student-to student interaction. In April of the first year when discussing WCD, Tracy said, "I'm trying really hard...to be the person that's there for back up...I'm holding back more" (TLPI y1r2). In trying to relinquish control, Tracy's classroom management goal was "Instead of me in the front, I wanted to be in the back, which I was for the most part, and sort of circling around (TLPI y1r2).

#### **b. Purposes for Whole Class Discussion**

Another change in Tracy's practice was the purposes for which she used WCD. Initially in the baseline data she spoke about using discussion for controversial topics to share information and to introduce new concepts. At the beginning of the TEFA project, she was using discussion to help students define and learn new terminology like valence and bonding. In the first video taped lesson during year 1, Tracy encouraged students to

use the scientific terms to “tell a story in your language” (TCOP y1r1). This is consistent with Tracy’s goals as espoused in the baseline TPPI interview that she wanted students to learn the “language of chemistry”. Near the end of the first year of using TEFA, Tracy had added using WCD to evaluate students’ thought processes to her list of purposes. Tracy also said that in the past she often used the lecture format to assist students to reach different conclusions about the different concepts that they were learning.

**c. Eliciting Students’ Thinking**

There was a shift in Tracy’s belief and in the way that she implemented question driven instruction and discussion in eliciting students’ thinking and guiding students to draw conclusions of what they were learning. The following excerpt gives insights of how Tracy was conducting whole class discussion when baseline data were collected.

<b>Excerpt 1</b> <b>WCD Pattern – Eliciting Students’ Thinking</b>
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**Teacher Actions**

Transmissive mode  
 Telling students everything  
 Asking questions and responding to them without chance to respond.

**WCD during Classroom Observation (TCOP y0r1)**

Tracy: Put these together. So we’ll all do them the same way. We’ll start by in the upper left hand corner in the boxes that you’ve just made, you’re going to write P compared or verses, it’s kind of like a competition, T. So that means what Tim? When we say P vs T? ...Pressure vs Temperature? What happens to the pressure when? Temperature... (inaudible) Yeah, you’re a ventriloquist (ha ha). What happens to the pressure when you change the temperature of the system? You know, imply when we say P compared to T. We’re going to say the volume can’t change and the number of particles won’t leak out, so we’re going to call them constant. Constant means that they will not change. We’re going to assume that if you have a spray can, an aerosol can, that it’s not going to expand in size, it’s got rigid size. It’s metal, like a Brill cream, a spray cream, shaving cream and that the number of particles cannot get out. Okay, so what happens if you take your shaving cream and you throw it in the camp

Questions to assess understanding	<p>fire? I know I haven't done it, but I know my brother did it - It Explodes! What can you say about the relationship between temperature and pressure as you made the temperature go up...The pressure went up. Very Good! Okay, so a note to yourself, as the pressure goes up... So underneath the symbol P, you're going to say as it goes up how does the temperature relate to that? It also went up. Does that make sense? Let's talk about why from a kinetic molecular theory perspective.</p> <p>That means we're going to pretend that we're really that molecule. What happens to a molecule if you make it get hotter?</p>
Continues with transmissive mode	<p>Tracy: Uh huh, the more thermal energy makes it do what? Move faster. So any time you change temperature you're changing the speed of those particles. Okay, so as the speed goes up what happens? Hint, hint, hint.</p>
Questions to assess understanding	<p>Student 2: More collisions.</p>
Continues with transmissive mode	<p>Tracy: More collisions. The faster they go they hit the walls more often and the pressure goes up</p>
	<p>Student 1: More thermal energy</p>

In the previous excerpt from the baseline lesson, Tracy is in a transmissive mode of giving the students most of the information, asking questions which she answered herself rather than letting the student think and come up with the answers.

During the first year of the project, Tracy was eliciting students' thinking more and giving students "more of a voice" (TPPI y1r1). This change in the way Tracy was running whole class discussion is also supported in the lessons that were video taped as indicated in Excerpt 2 below.

## Excerpt 2

### WCD Pattern – Eliciting Students' Thinking

Teacher Actions	WCD during Classroom Observation (TCOP y1r2)
Probes for better understanding	Tracy: You don't look happy Nathan. Why?

	Nathan: No, no shouldn't the other three be the same?
Probes assumptions/ perceptions	Tracy: What do you mean?
	Nathan: Shouldn't they have the same amount of precipitate, cause there are only ten Iodine in the rest.
Focus on understanding student's question	Tracy: So you are purposing that if we could get out a depth measurer tomorrow and look at the depth of one, two and four that they should be equally as deep.
Restates/rephrases for clarification	
Elicits students' thinking - encourages reasoning and justification	Tracy: And say again why you think that and I will write it.
	Nathan: With a one to two ratio of lead and iodine there should be five – only five lead and ten iodine in the reaction.
Probes assumptions & preconceptions	Tracy: Okay, so you are looking up here and saying there are ten leads that showed up to do the dance.
Probes for better understanding	Nathan: Yeah.
Probes for better understanding	Tracy: They only are going to be dancing with how many other iodine?
	Nathan: Five.
Probes for better understanding	Tracy: Out of ten iodines that showed up how many lead carbons do they dance with?
	Nathan: Five.
Encourages peer evaluation	Tracy: Five, so he is saying we only need five to accommodate these ten. You following his logic?

When comparing the previous excerpts – Excerpt 1 on page 139 which was taken from Tracy's baseline lesson observation to Excerpt 2 on page 140 and 141 that was taken from her lesson during December of the first year, changes were noted in how Tracy was running WCD and in her efforts to elicit her student's thinking. Tracy's teaching style was evolving into a more proactive learning approach than the class discussion that she had before using PRS. Excerpts 1 and 2 from Tracy's video taped

lessons are reflective of some of the changes in the way Tracy used whole class discussion from just basically transmitting knowledge to eliciting students' thinking by encouraging them to give their reasoning, justify their assumptions and provide rationalization for their choices.

#### **d. Summary**

The findings gave insights of how Tracy changed her way of conducting whole class discussion from a transmissive mode to a mode that elicited students' thinking. The tension that Tracy experienced with the amount of time needed for WCD was resolved when she recognized its effectiveness in formative assessment and eliciting student thinking. Tracy worked on the initial tension of controlling the discussion during the first year. This tension gave way to a secondary tension of her trying different ways to relinquish control. However, Tracy continued to grapple with this need to be in control during the second year of the project (TMR, TLPI y1r2, TPPI y1r1, TVBI). (See the timeline of tensions on page 122).

### **4. Student Participation**

TEFA encourages volunteerism when speaking and anonymity of responses in whole class discussion, whereas Tracy desired that all students be engaged and participate in discussion. This created tension as Tracy controlled the interaction during discussion to ensure that all students participated. Tracy continued to grapple with this tension in year two of the study, but the tension was less pronounced as she decided that she would still call on students to make sure they all participated in discussion despite what TEFA encouraged in this regard. One of the reasons why Tracy wanted to ensure

that all students participated in WCD was because of her belief that students should have integrity.

**a. Students' Integrity**

On the first TMR survey in October of the first year Tracy was concerned about students who never participated in class discussion and whom she felt were not engaged in class. She wanted to ensure that students were actively involved and also wanted to emphasize integrity. Tracy defined integrity as accountability, being honest, doing your own work, “Integrity: your work is your work and not someone else’s. Exercise your own brain cells” (TPPI y1r1) and not depend on the work and thinking of others. This is consistent with Tracy’s baseline belief that “integrity is something that I want to model and that I want to be an expectation in my classroom” (TPPI y0). In TPPI y1r1, Tracy also believed that students who were good or successful learners were “willing to accept responsibility in class discussion. Integrity is a big, big theme with me, so try the work” (TPPI y1r1).

In the Teacher Monthly Reflection (TMR) given October of the first year, one of Tracy’s considerations was that all students participated in whole class discussions. In response to question 3: Day-to-day, what aspect(s) of using PRS+TEFA have you been most focused on or concerned about during the last month? Tracy wrote, “Making all students join the class (*discussion*) and stay joined” (TMR y1r1). Tracy believed that students should show integrity and accountability in classroom discussion and called on them to contribute to WCD to ensure that they did. The following excerpt from the video taped lesson observation in December of the first year gives a brief glimpse of

how Tracy's belief that all students needed to participate in whole class discussion was enacted in the classroom.

Excerpt from WCD during Classroom Observation (TCOP y1r2)

Tracy: According to Elena, but ah okay, so . You understand what she said, which one did you pick?

Jill: I picked both two and three.

Tracy: You picked two and three, okay so we'll put stars here, these are Jill's picks. Why do you think both are a good choice?

Jill: Because they didn't have any added water.

Tracy: Okay that is your rationale, so we didn't have to add any extra water. So you picked them because that is what they had in common. **Okay, um, Sean?**

Sean: I picked two and three.

Tracy: You picked both. Can you tell me why?

Sean: For the same reasons. Like, I thought at first I was going to pick two because it had the most lead, but then Nate was talking about how you need two iodines for the reaction later, so then I wasn't sure so I thought it would be two or three.

Tracy: Okay.

Sean: It was a guess. Board said so.

Tracy: Well I can understand why you would pick two or three because the total-- kinda like what Jill said. The partners show up you don't have to add any water. **Hannah what did you pick?**

Hannah: I picked just two.

Teacher: You picked just two. How come?

Hannah: Because having less lead.

Teacher: So lead is the one that is of most interest to you.

Hannah: Yeah.

Teacher: Okay, yeah . **Who haven't I asked yet? Taylor, what did you pick?**

Taylor: Two.

Teacher: Two and your reasons?

Taylor: For some reason I thought lead in it was higher but, because I forgot what had the most.

This excerpt is representative of the way Tracy managed classroom discussion. After

asking a question and polling students answers, she typically asked individual students what they chose and to give reasons for their choice. The question, “Who haven’t I asked yet?” (TCOP y1r2) was Tracy’s way of ensuring that all students participated in whole class discussion. Tracy wanted to make sure that each student answered and if they did not volunteer, she volunteered them.

A year later, the data showed Tracy was still experiencing tension with requiring that all students participate in class discussion by calling on each one of them. In response to the same TMR question 3, she wrote, “Determining whether all students should be expected to participate” (TMR y2r1). The next excerpt shows Tracy’s response to one of the questions that was given for participants to reflect on before the December action research session during the first semester of the TEFA project.

Tracy’s response to the question indicates her assessment of the degree of fulfillment of her goals with regard to WCD and student participation in WCD. Out of 16 questions, Tracy chose question one to respond to - question 1: What were your goals for implementing PRS? To what degree have these goals been achieved? What has promoted and/or hindered the achievement of your goals? Tracy responded that her goals were: a) to increase student participation in class, and b) to facilitate class discussion. Tracy believed that goal "a" had “been met to my satisfaction. Students use and seem to like TEFA”. In analyzing this statement, Tracy seemed satisfied with her habit of calling on all students to respond during WCD in an effort to ensure that they were all engaged. This assumption is made because the lesson video-taped just before the action research session showed that Tracy was making sure that all students responded my calling on them. Tracy wrote that,

Goal "b" is in progress, but it is the goal through which I have achieved the greatest satisfaction, so far. Most students actually have been very good at describing what they believe to be "true" when I have used TEFA as a pre-assessment activity. These discussions have guided my lesson planning. I also think that students have improved their understanding of content by organizing and expressing their thoughts to the rest of us in the class. I am trying to adapt (remember to plan to incorporate) these types of activities when I begin a new topic (AR y2r4 12/18/06).

Tracy's determination to make sure that all students participated by calling on them continued throughout year 2 as evidenced in the AR sessions.

#### **b. Participation and Discourse Patterns**

Tracy was very pleased with PRS as a means to getting all students to participate. In April of the first year near the end of the Spring semester, all twelve of her AP Chemistry students participated in whole class discussion. Usually, only a few vocal students would participate. Tracy spoke about an increase in student participation and explained how she managed WCD, some changes she had made in this regard and benefits that were realized in the excerpt below.

Excerpt from TPPI y1r1 interview (Conducted the end of year 1)

Researcher: How do you run a whole class discussion?

Tracy: I usually am the person who poses the questions or I'm the one who says we're all gonna present our data in this format or here's a question and use PRS, what would you, uh, what would you choose as your answer? But I'm the initiator, I'm the one that starts the question and then from there, I would say that Allan (faculty facilitating the action research component of the SSSPD model) would see me more as a . more and more students are talking with students, but it still cycles through me.

Researcher: So if you were able to rate the amount of times that students are talking to students, how would you rate that, if you were able to say quantify it?

Tracy: Oh quantify it? As a percentage? Mmm, 30%.

Researcher: And, has this changed any from when you started at the beginning?

Tracy: Yes, it has a little bit. And I think, I think the intent of the PRS instruction was to get us to think about how we could hear more student discussion with other students and people challenging other students ideas, which I think is something I'm taking away from this class that's very good. I like how TEFA has worked for me sometimes in that it has. I've heard

more from the students and I think they've heard more from each other.

Tracy mentioned Allan and even though she did not finish the sentence, it is presumed that she was remembering action research (AR) session (y1s6), the sixth AR session done in March of the first year when different types of discourse patterns between teacher and students were discussed and modeled. This excerpt indicates that Tracy was thinking about discourse patterns and analysis in light of what was learned in the AR sessions and also indicates the impact that the AR session had on her awareness of her students' discourse patterns. Tracy also spoke positively about the impact of the PD component of the SSSPD model and its role in getting her to encourage more student-to-student exchanges during whole class discussion (WCD).

The depth of students' responses had also improved, which is also verified in the video-taped lessons. Tracy believed that there was "more engagement from at least some of the kids" (TVBI y1r1) and that the students had a higher confidence level. Additionally, Tracy believed that there were "deeper" and "more well thought out answers" and a "willingness to persuade others and defend answers to say that "I want you to understand it. I want you to buy what I have to say" (TVBI y1r1). Also, "the quality of the defense" was better than in the past (TVBI y1r1).

**c. Ensuring Participation in Whole Class Discussion**

The excerpt below shows what Tracy said about the evolution of the way that she managed WCD and in her questioning her belief that she should make sure that all students responded during discussion.

Excerpt from TPPI y1r1

Researcher: What are the characteristics of good helpful whole class discussion?

Tracy: Good listening, trying to engage as many people as you possibly can, but you can't always. I mean even if you call on some individuals they're either unwilling or unprepared to share in the discussion. So, as many voices as possible without creating too much discomfort. Am I answering that in a way that makes sense?

Researcher: Yes. Give me an example of what you mean by "as many voices as possible without making too much discomfort."

Tracy: Well, having watched myself on video, leading discussions, I do intentionally pick kids and try to put them on the spot sometimes. I'll say "So, you answered or you didn't answer and what did you say?" And sometimes I can't pull that kid into the conversation, they'll just say "I don't know." And whether I believe them or not I need to respect the fact that they don't want for all of us to wait for them to say something. So that's what I mean about the discomfort...if you put that person on the spot, knowing that they have the answer but they defer. You know what I mean? They say "Well, I'm not sure" and you're thinking "Yes you do know!" I don't think that I would pressure that student in front of the group and say "I know you know, you need to tell us."

In the previous excerpt, Tracy mentioned the role of the one of the strategies, watching her video taped lesson, used in the PD course in helping her to reflect on and analyze her teaching. She shared some of the insights that she got from this exercise. This is another indication of the impact the PD had on changes in Tracy's practice. The impact of TEFA PD will be described in Section F of this chapter.

Although Tracy was experiencing success with improved student participation, she was still grappling with whether she should put students on the spot and say, "I didn't hear from you" or "you have to respond" or still leave it up to them to respond if they wanted to. Tracy still felt that she had to have control over the discussion to ensure that all students participated because of her concern about the passivity of many students. Tracy was jostling with her belief that all students needed to contribute to whole class discussion and the volunteerism and anonymity that were being encouraged in the PD. She was wondering if maybe she wanted to actually continue calling on all students during discussion.

In October of the second year, Tracy was still experiencing tension with determining whether all students should participate in discussion, which she mentioned in TMR y2r1 and the action research sessions in the second year. See page 118 for the timeline of tensions experienced by Tracy. As year 2 progressed, Tracy was not as satisfied with student participation as she was during the first year. In the next statement, Tracy mentioned a possible reason for this decrease in student participation.

I wish that I hadn't let students believe that their answers would be checked...It felt coercive and I think it changed the dynamics in my target class, but students are forgiving (TMR y2r2).

The decrease in student participation in WCD during the second year may be attributed to Tracy telling students that she would check their answers to see how they responded. The statement shows the Tracy regretted taking away their anonymity. It is believed that this affected the students' participation because previously Tracy had told students that their responses on the histogram would remain anonymous (AR sessions). (See timeline of Tracy's tensions on page 122 for how long she was experiencing tension in these areas).

#### **d. Innovation - Role of Scribe**

An initial way that Tracy made innovations to TEFA to fit into her style of teaching was the emergence of Tracy's role as a scribe, which was not modeled in the PD course. As a scribe, Tracy kept track of students' arguments during whole class discussion by writing them on the chalkboard and using the arguments to further develop concepts and expand students' understanding (TCOP, TVBI, Journal y1 March). This emergence of what Tracy labeled as "scribe" and what she also referred to as "secretary" was influenced by Tracy's learning style. In the TLPI base line interview

that was done in May before the project began, Tracy spoke about the need to review and underscore important points.

In a philosophical sense I think it's good to look backward or to review or to go, to sort of seek the point where kids are supposed to be grounded and then put the new thing on it. So in terms of the way I like to learn, I would have loved if every teacher had done that for me and say okay, "Where are you? Do you know this new vocabulary?" I learn by writing what I'm saying and I think that many people are helped out that way (TLPI y0).

During the same interview, Tracy spoke about writing when working with a student individually to be better able to process what the student was saying which is indicated in the following statement.

I've had students in the past, they are very bright. They're auditory and they don't need it, they don't need to do that part but for me. I find myself when I sit next to a child and try to coach him I need to have a pencil to do the talking to process just what we're talking about. So I learn, and I know you can't see that on audio, but I learn by writing what I'm saying and I think that many people are helped out that way (TLPI y0).

Acting as a scribe was already ingrained in Tracy's practice before starting the TEFA project. Initially, Tracy acted in the role of scribe in small group and individual student interactions. Tracy's role as a scribe in individual student interaction and small group interaction at baseline evolved into being a scribe that facilitated whole group discussion when she first used TEFA with her students as indicated in the next excerpt. Tracy explained why her role as a scribe developed into keeping track of WCD and her reasons for operating in this role.

I want to try and direct the conversation... The first time I tried it, I had people saying things that were worth recording, were worth writing down. So maybe, in a way, it was Kismet. Then I thought, "Shoot, how am I going to keep track of this conversation?" Because I'm not good at remembering what everybody says. So, sort of the format started, for me, I had the question projected and, then I just started making little notes for myself. But then, all of a sudden, I don't know. It just sort of happened. People would say, "Well, wait a minute, I guess I do agree

with so and so." So now we're doing a little checklist, and then writing another idea and another idea...By putting it on the board, it makes it feel important to the student and to me. It's important to me 'cause it helps me remember it...But in terms of how I decided to do that, it wasn't conscious. You know what I mean? I didn't say, "Okay, we're going to document this." It just, I started recording. My kids said that it worked and people liked it too, because the next day, they would say, "Okay, remember what so-and-so said? Well, then, I don't think that's true anymore. And here's the reason why." So they went home, they thought about it and they came back, and I thought, "Yes, yes, yes! That's great. You took this beyond Room 8310." You know? That's good. So I, I've done it that way (TVBI y1r1).

As a scribe, Tracy not only wrote all the points that the students talked about during WCD, but she used them as a check list for exploring their thought processes, addressing misconceptions that surfaced during discussion. Tracy also wrote what students said on the board to link different parts of the discussion to make a point or to further develop or challenge students' thinking. While keeping track of students' argument on the board, Tracy was careful to not make any judgment about their correctness or accuracy.

Tracy's role as a scribe was a valuable strategy for formative assessment and to transform students' thinking as indicated in the excerpt below;

Faculty: So I never really thought about that. One of the purposes of using the TEFA and PRS, is that, I don't know whether the guys (*other faculty doing the PD course*) haven't been explicit about it or they haven't thought about it in this way, but I didn't think about it until I interviewed Tracy...That is, using it for instructional purposes, so the main way in which I think that you've been talking about it is formative assessment. How do you gain information about what the students are thinking and how they're thinking about things? It can also be used to transform the way in which your kids are thinking. And when it's used in that way successfully then I think it justifies the time that's required to use it - when it's used for instructional purposes to transform students' thinking (AR y1s5 2/26/08).

Tracy's role as a scribe for whole class discussion was a way of using TEFA and PRS as an instructional tool that the faculty facilitating the PD did not think of before she started doing it. One of the faculty facilitators points this out in the previous excerpt which was taken from the transcript of the fifth action research (AR) session during the first year of the study.

**e. Summary**

After wrestling with the tension of making sure that all students responded during WCD for months, Tracy appeared to have decided that this was one thing she was not willing in change. Near the end of the first year, all of Tracy's students were participating and more were volunteering to respond which was evidenced in the video-taped lesson, TEFA Classroom Observation Protocol (TCOP), which was done in April of the first year. At the end of the two years, she was still making sure that all students responded during WCD, but was allowing more student-to-student communication.

Tracy's emergence as a scribe to facilitate WCD occurred early in the year. Tracy's learning style influenced her innovation of the role of a scribe. Although Tracy did not identify herself as a scribe in the baseline data, she mentioned that she liked to write everything down to keep track of what students were saying in small group and individual student interactions. This evolved into her being a scribe to facilitate WCD. In the role of a scribe, Tracy used the board to keep track of students' arguments and as a reference point to further develop concepts, check students' understanding, elicit their thinking and set the stage for further exploration and debate the next day. Faculty facilitating the TEFA project saw the emergence of Tracy's role as a scribe as an

innovative way to use PRS as an instructional tool which they had not thought of or modeled in the PD course.

In the previous part of Section D, changes that occurred in Tracy's practice in regard to closure and summarizing of Tracy's lessons, whole class discussion, student participation and Tracy role as scribe were discussed. Now in the last segment of Section D, I will examine tensions that Tracy experienced with depth versus breadth when covering the curriculum, with the time it took to implement TEFA, and the problems she was having with fitting TEFA into her practice. I will also explore the ways in which Tracy used TEFA and PRS. I will use data to outline the changes that occurred in Tracy's practice as she grappled with and resolved some of tensions that she experienced.

## **5. Curriculum Integration**

During the first year, especially during the first semester, Tracy experienced difficulties in integrating TEFA into her curriculum. Teachers often find fitting TEFA and PRS into their curriculum the most problematic aspect of learning the new pedagogy when compared to other aspects of the TEFA. The difficulty arises because TEFA and PRS are not an integral part of existing curricula and supplementary materials (Feldman & Capobianco, 2007). For Tracy, time was a strong factor that had an impact on her integrating TEFA into her curriculum.

### **a. Time Factor**

Time was a major factor in some of the tensions that Tracy was experiencing. There were three aspects of Tracy's practice in which time was an issue. At the beginning of the study Tracy was concerned about the amount of time needed to

implement TEFA. Tracy also wrestled with writing questions because she did not have enough time to devote to write questions that elicited and challenged students' thinking. The third aspect of Tracy's practice that was influenced by the time factor was her problems with "fitting" TEFA into her practice. When speaking about fitting TEFA into her practice Tracy explained, "It's time for me more than anything else. It's a busy, full life. It's not actually sitting down and saying – if you look at my plan book, my plan book is very sketchy" ( TLPI y1r1).

Tracy's idea of what she considered valuable use of classroom time was one of her beliefs that changed as she participated in the study. At the beginning of the project, Tracy was concerned about whether the benefits of TEFA justified the amount of time needed to implement it. Time was also a factor in Tracy's infrequent journal entries. Tracy believed that one of the factors that caused her lack of time was the large amount of time that she devoted to writing detailed prescriptive comments on the homework. When speaking about homework in the baseline interview Tracy said,

I look at the homework, and I write back to the students. And it's tedious as heck, but it's worth it because that's how I get a sense at least how to steer the ship (TPPI y0).

When thinking about what she would do for her action research project, Tracy was thinking of researching different ways to reduce the time she spent on grading homework. Tracy stated, "I'm toying with the idea of not grading homework. I have a homework policy that eats up a lot of my life" (TPPI y1r1; Journal 11/18/06; AR y1s3, s4). At one point, Tracy was thinking about investigating whether "TEFA could be a quicker less tedious way to check in on students' progress (*for her action research project*). I need to think this through some more, though" (AR y1r4 12/18/06). Tracy

gave homework nearly every night and gave it back the next morning. She had what she described as an edit, repair and resubmit homework policy and would see papers two and three times. Homework accounted for 15% of the grade for the semester and all students had “an ‘A’ guaranteed because they've edited and I give them permission to repair” (TLPI y1r1). Therefore, students had the potential of getting an “A” in Tracy’s homework assignment if they took advantage of her edit and repair policy.

**b. Depth vs Breadth Coverage of the Curriculum**

Tracy was experiencing tension because TEFA encourages focus on students’ depth of understanding concepts, but Tracy was concerned with covering enough of the curriculum. This tension was resolved as Tracy’s belief about keeping a rigorous pace to cover the curriculum changed. This belief changed as Tracy saw the positive impact that TEFA had on helping her students have a deeper understanding of the content.

At the beginning of the TEFA project, Tracy was very content driven. She believed that, “Primarily, since I'm teaching high school, upper level, I have a responsibility to content, so the material that I teach it's really important to me” (TPPI y0). Tracy rationalized that since her AP Chemistry was test driven that she had to cover the curriculum in a set time for that purpose. During the baseline data collection, Tracy said she did not experience any tension with the amount of material in the curriculum and felt that certain topics had to be done, while “others have to be pruned” and she had no problem with that (TPPI y0). Tracy reiterated this when she said that she had to “trim and budget” (TLPI y0) to make sure she did the topics she still had to teach. Early in the study, Tracy had already started experiencing tension with covering the curriculum because she believed that it was “a risk using TEFA and PRS too often”

because of the time factor and what she perceived as a “tug-of-war between effective teaching and working for their retention and covering what you can cover” (TLPI y1r1).

In TPPI y0 which was conducted in July 2006, and in TPPI y1, which was conducted in May 2007, Tracy made the statements below when speaking about covering the curriculum.

Sometimes teaching to me is like rolling a **hoop** in a way. I mean you're constantly trying to keep it upright so that everybody's with you at the same time and moving forward (TPPI y0).

I'm responsible for evaluation at various steps along the way, so assessing how fast the **ball** should roll, and that metaphor makes sense. I sort of see teaching in a way as sort of keeping the hoop going but making sure it doesn't get away from you. So sort of gauging when to speed up and slow down (TPPI y1).

Tracy compared her responsibility to keep the pace moving to rolling a hoop or ball.

The main things that stand out in the two excerpts are Tracy's beliefs about staying on track, always moving forward with the curriculum, having control over what is happening and making periodic evaluations. Tracy's need to keep a rigorous pace was reflected when she said, “I do a little bit of re-teaching in the very beginning, but it's short and fast and we then move from there” (TLPI y0). This statement suggests that she had a time limit to re-teach and then she must move on. Tracy alluded to her belief that it was her responsibility to keep a rigorous pace several times during the lesson planning interviews. In TLPI y0, Tracy described shortening a unit as “taking a shortcut and taking that risk” to “speed up” the unit by compressing two days teaching into one day; a process which she labeled “trim and budget”. Tracy felt that speeding up the unit was necessary as the semester was winding down and a lot was still left to teach. Tracy also spoke about changing the pace of her teaching depending on the group when she stated,

“We really cruised this past week and it’s because they’re pretty bright, they’ve got good math skills and I would in the past slowed it down” (TLPI y0). Tracy inferred this need to keep moving forward when she stated, “we keep a pace, it’s not slow” (TLPI y1).

Tracy struggled with her belief of keeping a rigorous pace to cover the curriculum but by the end of Fall of the first year this belief was changing. Although the need to cover the curriculum remained one of her top priorities and Tracy was still wrestling with it by the end of Spring of the first year, she conceded that it was acceptable to budget more time to use PRS because developing students’ reasoning skills was more important than covering content. (See Figure 3 on page 122 for timeline of Tracy’s tensions).

By February of the first academic year during the TVBI interview, Tracy admitted that going slower may be better, but she was still wary of slowing down in her target class, AP Chemistry because of her need to cover the curriculum for the exam.

The following excerpt reflects her changing belief about covering the curriculum.

I like the conversation (*whole class discussion (WCD)*) part of it. Sometimes students have said it's slower. The pace of the course feels slower using TEFA. And I think--I'm not really sure why they perceive the slower in the negative way, 'cause sometimes, and maybe I'm interpreting it that way, but...slower isn't necessarily bad. I think, culturally, here in school, and maybe you can take this out to the overarching society, but, slower may be a good thing for the majority of the kids in the group. I mean, if we really slow down and ask ourselves, why are we accepting this, other than there's an equation in the book? You know? So I like the slowdown of it and I'm kind of lying too, because I've not used it sometimes in my AP class, 'cause my AP class has a deadline, has an exam, it's on...May 15th, and I've got to cover a certain amount of material. Philosophically, I still wonder when to "wander off-topic with them" sometimes, because we need relevance for all the things that they're covering. ...So the slowdown part of it, kids have said, "Yeah, clickers make things go slow." But, slow might be good. I wander a lot (TVBI y1r1).

The data showed that Tracy's beliefs were evolving. Although Tracy's belief about needing to keep a rigorous pace to cover the curriculum was evolving, she was still jostling her need to cover the curriculum with using discussion to elicit thinking. Tracy considered these two needs as in opposition to each other. She admitted that she was being contradictory with what she now believed to be true about slowing the pace in one of her classes, but she did not believe it enough to try it with her AP chemistry class. She stated, "I'm kind of lying too, because I've not used it sometimes in my AP class". The following excerpts are reflective of Tracy's changing beliefs about her need to cover the curriculum. Her statement below attests to this.

But then you say to yourself, "But you covered it, but who cares?" Because if they didn't get it it doesn't matter. And so, I think that's the one thing that I think a lot about with choosing PRS. Because it took, to do this actually portion of today's class, it took us about a half an hour (TLPI y1r1, Nov).

The next three excerpts from Tracy's journal, from the lesson planning and the philosophy and perspectives interviews conducted during the second semester of the first year are included to further triangulate this change in Tracy's beliefs about covering the curriculum.

It (*TEFA*) is most useful when I want to generate class discussions. However, using PRS in this manner takes time. Currently, I am wrestling with the time issue in the context of understanding versus breadth of content. I'm leaning toward depth...The goal of teaching for me has shifted gradually from a very content oriented process to a mission that still focuses on content but puts increasing emphasis on the importance of learning how to be a good learner (Journal, April y1).

"I think this", when referring to using whole class discussion with PRS, "is a better exercise educationally than was zinc? Who cares in a day or two? But what was important was whether you were able to persuade other people to make your choice is really more powerful I think. So, I liked this activity, I'll definitely use it again, and I think PRS lends itself well to it because it was quicker... I think their performance the following day made me know that it was

worth the time. There were fewer people asking me, "What do I have to do next?" (TLPI y1r2, April).

The whole class discussion piece of it, I plan to keep using. It's convinced me that it's worth the time more often than not, because in a funny way I've had to double back because I didn't know that kids have misconceptions, or people did poorly and I didn't know why. And I think it was because I never asked. You know what I mean? I never really gave them a chance to say "Well, yeah, I think that, you know, electrons are like this." And you say "You really do? Okay" (TPPI y1r1, May).

In the first excerpt from Tracy's journal, she stated that she was "wrestling" which indicates the tension that she was experiencing in regard to depth verses breadth when covering the curriculum. Although Tracy was still experiencing tension in this regard, this tension was being resolved as she realized the benefits of TEFA pedagogy in helping her identify students' misconceptions, encouraging her students to be proactive learners and helping them to improve their performance. At the end of the first year, Tracy said that using TEFA and PRS and having discussions were easier for her "because I think depth of understanding is more important...and that it was really, really more important than getting through all of the content" (TPPI y1r1). Tracy now justified the time spent on discussion, "I think their performance the following day made me know that it was worth the time. There were fewer people asking me, "What do I have to do next?" (TLPI y1r2). Tracy's belief that TEFA required too much time which may have hindered her from keeping a rigorous pace to cover the curriculum had changed as indicated in the next excerpt.

PRS, in general, you need to budget more time for it which is okay. Philosophically I'm all for that because I got a good amount of information. Kids were engaged, the time went by fast. I mean it wasn't dull. It wasn't dull". (TLPIy1r1).

The tension that Tracy had with the time needed to cover the curriculum was resolved

by the end of the first year. After this tension was resolved, Tracy approved of budgeting more time to do TEFA because of the information she got from students with regard to their understanding of concepts, the level of engagement of her students, and because she felt that the lessons were more interesting.

**c. Integrating TEFA**

Although Tracy had experienced early benefits from using TEFA during the first months of the project, she acknowledged that she was experiencing conflict with where she could fit TEFA into her lessons and not using TEFA and PRS as often as she had liked in many data sources. “So my starting point question is, “Why am I not incorporating PRS questions as frequently as I would like?” (AR y1s2). For a time Tracy grappled with where TEFA would fit in the sequence of her units, into her lessons in the unit and where TEFA would fit in her style of teaching. There was change in Tracy’s planning as she had time over the Thanksgiving holiday to plan where she would use TEFA and she experimented with TEFA to see where it could fit into her planning. In November of year 1 Tracy stated,

I kind of wrestle with - I'm trying to rationalize in my mind why is it that I don't choose this more often and that (*PRS segment of the class taking 30 minutes*) might be why. It could also be that I'm just lazy. Who knows? I don't think so (TLPI y1r1).

There was dissonance between Tracy’s old style of teaching and her perception of what needed to be done to modify her teaching style to integrate TEFA. Tracy noted her difficulties with integrating TEFA into her teaching in the following excerpt;

Here's where I'm having my planning difficulties. Finding places in my old style where I fit PRS in. I liked the way PRS worked for me today. But it's a conscious effort to say, "Where will this fit?" You know what I mean? It doesn't

have a -- it's not begging to be used. And when you're busy, you know how things have worked and not worked in the past. And I like PRS, but on the surveys that I've been answering on the internet, the hardest part for me right now is finding places to put it in. Making the time in my lesson planning to make it go in here. So over Thanksgiving when I had four days and I knew I was going to meet you, I said, "Okay, I know where we could put PRS here." And it worked out. And I think it can fit in more places. And that's a whole other conversation, too. Whether you use it -- and tell me if I should stop talking... And sitting down over Thanksgiving gave me time to say, "Okay, where could PRS fit into the way this has always rolled?" I mean the sequence is pretty much the same. I mean, yeah you can vary it somewhat... So I really do need to make more time for it in my planning (TLPI y1r1).

Five months later Tracy believed that it was getting easier to integrate TEFA into her practice as reflected in this statement;

I'm trying more and more, and it's coming more easily, to incorporate TEFA. I don't think so much about the technology piece of it at all anymore... But it's becoming - and it's almost like anything that you learn for the first time. It starts to get into your rhythm after you've used it a couple of times and you've really sort of felt like it's been worth it. I don't think so. I'm trying more and more, and it's coming more easily, to incorporate TEFA (TLPI y1r2).

Although Tracy got a better sense of where to use TEFA in her lessons in

November of the first year and was feeling more comfortable with integrating TEFA into her teaching in April, she still grappled with making it fit into her teaching.

Tracy's concern about fitting TEFA into her teaching was a tension that did not stop her from using TEFA, but influenced the frequency with which she used TEFA and PRS.

Tracy's tension with fitting TEFA into her teaching seemed to be resolved before the end of the first year. However, more than one year later in January of the second year in the monthly survey Teacher Monthly Review (TMR y2r4), to question three, Day-to-day, what aspect(s) of using PRS+TEFA have you been most focused on or concerned about during the last month? That is, which most demand your attention? Tracy responded, "incorporating it into my planning". (See timeline of tensions on page 122).

Tracy attributed the resurfacing of the tension with fitting TEFA into her teaching with the transition from the first term to the second term and to her having a new group of students. Tracy believed that she needed to “get back in rhythm” (TMR y2r4) with the new group.

**d. Uses of TEFA and PRS**

Tracy’s level of usage of TEFA and PRS increased as the study continued and at the end of the study she was using TEFA and PRS in more diverse ways. Three months after the study began Tracy admitted that she did not “do it (*use PRS*) consistently because I’m not prepared to do it consistently” (AR y1s4). As the first year progressed, Tracy incorporated TEFA and PRS into her practice with more use although “it’s been gradual” (TVBI 1r1). Tracy used TEFA and PRS in a variety of ways. “I’ve tried to use it as an instructional tool in ...laying the ground work like a logical proof. If this is true and this is true, then what else do we know?” (TLPI y1r1). Her students told her, “We don’t like when you teach us this way” (TLPI y1r1), but she continued to grapple with using TEFA as an instructional tool to illicit students’ thinking despite her students’ frustration. Tracy also used the TEFA and PRS to check students’ understanding of scientific terms, and “used PRS successfully... *and was* very pleased with it as a way of diagnosing preconceptions or misconceptions and I like it very much for that” (TLPI y1r1).

At first, Tracy started using TEFA and PRS to assess students’ preconceptions but as she developed more skill with eliciting students’ thinking, Tracy was very pleased with the capacity of TEFA and PRS to diagnose and address students’ misconceptions in real time. Before her participation in the TEFA project, Tracy used informal

feedback while she was teaching and even used students' non-verbal cues in addition to formal feedback to assess their understanding. In the baseline TLPI interview, Tracy said she looked at her students' faces and body language as one of the means of assessing whether they were understanding what she was teaching and as an indicator that her lesson was successful. "I want to gauge by looking at their level of discomfort" (TLPI y0).

In the past, Tracy had made assumptions about whether students understood a concept or not and sometimes it was not until after a quiz a week or more later that she realized that some students did not understand. In February, Tracy was singing the praises of TEFA and PRS for revealing the misconceptions that her students had about heat transfer and the role of the new pedagogy in guiding what she did in the classroom.

"Wait a minute, they need to actually do this." So we did a little mini-lab. They wrote up what they thought the hypothesis was and then I discovered that they're really sloppy, in terms of what they controlled. There were so many things that we actually ended up talking about - same time last year, same unit, I would be cruising on to Hess's Law, and feeling good about it as a decision. As a teacher saying, wait a minute, if they believe this, we can't go on to Hess's Law (TVBI y1r1).

By the middle of the second year of the study, Tracy's comfort level with using TEFA and PRS had grown and she was using them in more diverse ways including to check homework (TMR y2r, y2r2), to pre-quiz for upcoming quiz (TMR y2r3) to review and re-teach concepts at the end of units and to learn new vocabulary (TMR y2r5, y2r6, y2r7) and to motivate students as reflected in the following excerpts from action research sessions;

What I am really interested in trying to get students to do is prepare better outside of class, so I guess what I am trying to explore is can I use PRS as a way

to check in, slash, motivate kids to do reading before they get to class (AR y2r4).

I want to use PRS and model using PRS as a tool, not as a necessity for every day. In the lines of a pre-assessment tool or a check in on the homework, and you assume that they knew that protons are positive or negative or what ever, and then diagnosing from there (AR y2r6).

**e. Metacommunication**

Another way that Tracy changed was her use of metacommunication.

Metacommunication includes communication that tells students what they are going to learn, the purposes for learning, how they should approach learning, how they should think about and assess learning and how they would benefit from learning the concepts and the skills. These are essential skills for effective intentional proactive learning.

Metacommunication lays the groundwork for students to engage in self-directed and other directed learning which is essential for them to achieve competence and mastery in subject knowledge and skills (Bransford, et al., 1999). Using metacommunication was not observed in Tracy's lessons early in year one, but she increasingly used it as the study progressed. Using metacommunication was a definite change in Tracy's practice. This was a new role for Tracy. "Teachers, like students, take on new roles when PRS is used in the ways envisioned by the PIs [Principal Investigators]" (Feldman & Capobianco, 2007, p.33). Tracy's use of metacommunication is reflected in the statement below.

That's another thing about me that's changed over time as a teacher. Why not tell them that you are also learning as you go along how to be a teacher, and that you're improving and that you're tweaking things and, "Here you are, you're my test subject, and I'm going to try this on you and you're going to let me know how it feels" (TVBI y1r1).

Tracy acknowledged that using metacommunication was a change in her practice.

Tracy's use of metacommunication is also supported in her video taped lessons in the throughout year 1 and became more pronounced in the lessons observed in year 2.

**f. Summary**

During the two years of the study, the evolution of change in Tracy's practice was characterized by gradual but steady changes done in incremental stages as she dissected TEFA into manageable chunks and tried out little parts of the pedagogy at a time. Tracy gained confidence and competence in different aspects of the new TEFA pedagogy. By the end of the first year of the study, Tracy's tension with depth verses breadth in covering the curriculum was resolved with her acknowledging that depth of understanding was more important. At the beginning of the study, Tracy experienced tension with integrating TEFA into her curriculum which she attributed to the issue she had with not having enough time to plan where to put it. By the end of the first year, this tension seemed had resolved but resurfaced during the Spring semester of the second year when Tracy had gotten a new class. Tracy diversified her use of TEFA and PRS and had changed her teaching to include metacommunication.

**E. Conclusion**

In this section, the data was examined in relation to the first secondary research question, How has the participant's practice changed over a period of two years as she integrated TEFA pedagogy into her practice? I discussed what the findings revealed about changes that occurred in Tracy's teaching using the four constructs of Feldman and Capobianco (2007) model of teacher learning of TEFA. Change was observed in Tracy's skill and knowledge in question construction, pedagogical methods and curriculum integration. The change was a slow process by Tracy's own admission and

was characterized by Tracy's segmented learning approach of breaking TEFA pedagogy into small manageable parts that she built confidence in before giving more focus to other parts of TEFA that she may have tried but had given less priority.

There were many changes in Tracy's teaching. The changes in Tracy's teaching were preceded by tensions and struggles that Tracy had to continually confront as she reflected on and analyzed her practice. Tracy experienced tensions in several areas while implementing the TEFA pedagogy. Many of the tensions were resolved as Tracy modified and refined TEFA to better suit her needs and the needs of her students. She continued to experience a few minor tensions in the second year of the project. See timeline of tensions that Tracy experienced in Figure 3 on the page 122. As Tracy examined the impact that TEFA and PRS had on her practice, the benefits accrued from TEFA facilitated the resolution of her tensions and provided justification for adopting TEFA which led to transformation in her practice.

As Tracy adapted TEFA to make it fit into her practice, changes occurred in her beliefs, in her skills and in her use of TEFA. Changes were made in Tracy's beliefs about covering the curriculum and about the amount of time she needed to plan to implement TEFA into her curriculum TEFA. Tracy developed new skills in writing effective TEFA questions, in conducting and managing whole class discussion and in the structuring of her lesson to bring closure. Tracy changed TEFA to conform to her way of teaching by becoming a scribe and designing a new type of question. At the end of this study, Tracy's practice continued to evolve and she was using TEFA in different ways to help her achieve other learning goals including tying TEFA to homework and exploring ways to use TEFA to increase students' motivation.

## **F. Facilitators and Precursors of Change**

This section examines the data to answer the research question, Are there predictors that may facilitate change in the practice of this participant? If so, what are the predictors that assist the participant to integrate TEFA into her practice? Seven factors emerged from the data that could be considered as precursors or facilitators of the changes that Tracy made to her practice while learning and adopting the TEFA pedagogy. These factors were Tracy's: 1) confidence and competence; 2) self-reflection; 3) learning style; 4) expectations for the PD; 5) perception of the nature of science; 6) expectations for her students; and 7) early success with TEFA. Most of the findings in this section are from data taken from the baseline interviews before Tracy began the project because they indicate her initial beliefs and mode of practice as a teacher.

### **1. Confidence and Competence**

Tracy was a teacher with strong content knowledge who was very confident in her ability as a teacher in the AP Chemistry course that was the target course for this study. Tracy was a competent, traditional teacher who had great expertise and skills in delivering successful lessons, managing classroom discourse and interactions and in encouraging her students to be engaged and proactive learners. She was comfortable with the technology required to implement TEFA. Being competent, positive and enthusiastic were strong attributes of Tracy's personality, which were revealed during the TEFA PD sessions, the interviews and the video taped lessons and in the other data sources. Tracy valued professional development and enjoyed being a student with a willingness to learn something new and to be assessed. "Every summer I like to do

something just to keep my brain fresh” and to “spice it up” (TPPI y0). In the Teacher Lesson Planning Interview (TLPI y0) that was conducted in May 2006 to collect baseline data Tracy said, “After teaching so long, you get bored” and that she made changes to her lesson plans before using them again for her “own entertainment” and that “you need to keep it fresh”. During the first year of the project, Tracy reiterated this when she said that she had to “vary it (*her lesson*) to keep myself from getting stale” (TLPI y1r1). Before making these statements, Tracy said rather apologetically, “This is going to sound awful in the replaying” (*of the tape-recorded interview*) (TLPI y0). Nine months after starting the TEFA project during the TPPI y1 interview, Tracy also said that what she liked about the TEFA pedagogy and the technology was that they helped her to reflect on her teaching more than she did in the past.

## **2. Self-reflection**

Self reflection is essential for teachers to gain insights about themselves and their practice and for them to improve what they do in the classroom (Feldman, 2003). Tracy was very reflective of what she was doing and often spoke about the need to assess herself. Tracy constantly questioned different aspects of her teaching. She exhibited self awareness of who she was, what she valued and what she did. Tracy’s reasons for doing what she did were considerations that she kept in mind when analyzing her practice. One of many examples of Tracy questioning her practice was noted at the end of the first year of the TEFA project, when she questioned, “Why am I not using PRS more?” to which she responded, “Well, maybe it’s because I’m lazy, but I don’t think so” (TPPI y1r1). Tracy’s ability to be reflective and analytical of her practice helped her to develop expertise in adopting TEFA. According to comments

that Tracy made throughout the study which were reflected in the data, Tracy's participation in TEFA had raised her self awareness and helped her to better define who she was as a teacher.

### **3. Learning Style**

Another factor that influenced Tracy's receptiveness to TEFA and that had an impact on the way she used TEFA was her learning style. A teacher's identity and image as a teacher are shaped by multiple experiences including influences of role models and personal experiences which have a strong impact on molding, informing and reforming the teacher's practice (Page, et al, 2004; Levin & Wadmany, 2007).

Additionally, teachers' beliefs about good and effective learning practices determine how they teach their students (Gudmundsdottir, 1987, 1995; Shulman, 1987, 1990; Haney, et al, 2003; Levin & Wadmany 2007). During this study, Tracy gave little snippets of herself as a student and about her learning styles which had an impact on what she did as a teacher. Tracy described her learning style as,

I think that there are students who are learners like I am. I like to try it on my own, meet the group, talk a little, and then go back on my own, and fix and then check...sort of like 'did I get it?' (TPPI y0)

Tracy acknowledged that she was imposing her learning style on her students as reflected in this statement,

The most beneficial thing that a student could do to improve his or her learning is to do a little bit at a time, although that's really imposing my learning style on someone else (TPPI y0).

Tracy reiterated her preference of using small methodological steps while learning several times in various data sources. "I believe that the slow and steady method of learning is – it's paid off for me" (TPPI y1r1). Tracy's belief in the slow and steady

method of learning was also supported when she said, “I’ve incorporated TEFA more - well, it’s been gradual” (TVBI y1r1).

Tracy’s learning style manifested during the project with her focusing on different aspects of TEFA in small segmented chunks. This aspect of Tracy’s learning, was also reflected in the TEFA Monthly Reflection (TMR) surveys which included open ended questions asking about what aspect of TEFA the participants had focused on in the previous month. Tracy’s learning style is also reflected in the way she discussed what she was doing with her colleagues in the PD course and in the action research sessions and the way she reflected on what was said and re-evaluated what she was doing based on the collegial interaction.

#### **4. Expectations for Professional Development**

During the baseline TPPI interview, Tracy mentioned several expectations that she had for the TEFA professional development which included: 1) technology that was easy to use in the classroom, 2) new pedagogy that was useful, and 3) immediate feedback about students’ preconceptions and understanding of concepts.

Tracy was “hopeful to sort of transition to the TEFA” (TPPI y0) project and that it had,

technology that I can use in the classroom--that's the first and hopefully I have some sort of a comfort level with it, so that it's something that's first on my mind and easy to use. Professional development...I'm not expecting to learn a lot of new chemistry. This is more a pedagogical exercise for me, but that's good. That's very good (TPPI y0).

Tracy believed that TEFA would help her know what type of assistance to give her students which is indicated in the following statement.

I'm hopeful that this (*TEFA*) project is going to offer me more immediate, not overnight, feedback, but perhaps more immediate feedback. In AP Chemistry

class, that's where, I think, some people start to fall off the boat and then they don't tell me until a week or so, and we're keeping the pace. I'm hopeful that the technology we're going to learn about gives me a sense of when to offer the assistance, especially since sometimes kids are reluctant to ask for it (TPPI y0).

In addition to offering timely assistance, one of Tracy's main concerns was keeping a "rigorous pace" (TPPI y0; TLPI y0, y1r1) to cover the curriculum and she was hopeful that the TEFA pedagogy would help her fulfill this purpose.

## **5. Nature of Science**

Tracy spoke about the nature of science in response to question four in the TEFA Philosophy and Perspectives Interviews (TPPI), "What do you think makes something scientific knowledge rather than other types of knowledge?" Tracy's responses to the question in both TPPI interviews were very similar. In the first interview conducted in May before the TEFA project began to collect baseline data (y0) her response was, "Scientific knowledge almost invites other people to challenge it" and it "should not be taken at face value" (TPPI y0). During the second TPPI interview (y1r1) done one year later in May, Tracy's response started with virtually the same statement as reflected in her statement below.

By nature of being scientific knowledge it needs to request or imply that you ought to challenge it and that's something that I've tried and been a little more successful with while using TEFA. Actually having kids tell me "I don't believe you" is really good. To say "I don't get that, I don't think that's what it is." And that's what makes science to me more interesting in a lot of ways, because it's meant to be challenged...There's sort of a concrete structure to science that says "you challenge it and there are certain ways that you challenge science that everybody agrees to this format, and we want you to do that" (TPPI y1r1).

Tracy explained that TEFA encouraged her students to challenge what they were learning. Tracy also credited TEFA for helping her to be more successful in challenging what students were learning. From the previous statement, the assumption is made that

Tracy was encouraging students to challenge science knowledge before using TEFA with very little success and using TEFA had resulted in her being a “little more successful” (TPPI y1r1) with this goal. Tracy’s statement about science inviting challenge supports Tracy’s belief that her students should be proactive students who should be actively involved in their learning, who challenged other person’s opinions, who provided evidence for their opinions and who tried to convince others to accept their opinions. Tracy’s expectations for her students are discussed in more depth in the next section.

## **6. Expectations for Students**

Tracy mentioned her philosophy of challenging students and encouraging them to figure things out on their own in the baseline TPPI y0 and also in the TLPI y0 interviews. In speaking about challenging students, one consideration that Tracy had when planning her lessons was thinking whether activities “would have been too easy and I don’t want it too easy either” (TLPI y0). She wanted to encourage students to assess their learning and discover their own problem solving strategies. Tracy stated,

You don’t say here’s this kind of problem, here’s how we’re going to solve it. You give them the problem and say, How do you think you would? (TLPI y0)

Tracy believed that students should be advocates that were persistent in getting what they need to learn and felt that it was “important to sit and listen to students...sort of assess their own learning” (TPPI y0). Tracy’s belief that students should be advocates is triangulated in the following statement.

There's a certain power in being able to defend what you have to say in front of you peers and I think that that's a good thing (TLPI y1r2).

As proactive learners and advocates, Tracy expected students to be committed to finding solutions that worked for them, to justify their answers, to stand up for what they

believed, to defend their choices and to have the courage to disagree with others and try to persuade others to accept their answers. Tracy's philosophy about students being advocates was also supported in the TEFA Video Based Interview (TVBI) and evidenced in her video taped lessons. Tracy wanted "students *to be* more willing to defend their answers – "leave it for other people to either accept or discuss, and that has appealed to me as a teaching technique" (TVBI y1r1). She believed that it was important to "try to let them know that you trust that what they say is going to be credible...you get more and how did I know that? I don't know (TVBI y1r1).

In addition to encouraging debate between her students, Tracy also encouraged students to challenge her because, "I don't want to have just one position be the only position" (TPPI y0). As advocates, Tracy also believed that it was the students' responsibility to speak up for themselves and say when they did not understand as reflected in this statement,

The other thing that's scary and I would like students to get over because it took me a long time to get over as a student, is seeking help, I mean really if you are lost, there shouldn't be a whole lot of shame in that. I know, for a lot of students, and myself included as a student it's hard to come and say "I really don't get this and I feel kind of stupid...help me," so that definitely is a student responsibility (TPPI y0).

Tracy also believed that her students should speak up when they did not agree with something. She stated that,

On the very first day...it's written in the syllabus...'ask me, and you know, I'll disagree with you, and my word has to have more weight sometimes than yours because I'm the teacher. They pay me money to do this, but I would rather have a student come and ask" (TPPI y0).

Tracy let "students know that it's fair for them to challenge what I've said as long as they have a defense for it" (TPPI y0). Tracy wished that she had the courage to speak up

about what she did not agree with when she was in school so she encouraged her AP Chemistry students to do so. Whenever speaking about her expectations for her students, Tracy emphasized “advocating for yourself - if you think that the teacher made a mistake, and this is a lesson that I learned late, go and ask” (TPPI y0). One year later, Tracy was still emphasizing her belief that students should be advocates when she stated,

I think that there are some students who actually come into my classroom and they have developed the skills that give them the confidence to say "No, I disagree." Or "This is what my records show," or "You said two days ago that this is the case and you're saying something else?" ...I think adults that have become good learners do feel like they've come with a certain set of skills, and that they're entitled to respectfully challenge the teacher and request that things be changed or altered. I don't always say "Yes," but I really do like that students will say to me, "You know, when you asked that question on the quiz, I don't think that was a fair way to ask it." And if you can defend your position, that's awesome, it really is a good skill for life (TPPI y1r1).

The excerpt above reflects one of Tracy’s goals of helping her students develop life skills that could be applied in wider contexts out of school and that could help them in their future.

Tracy knew what she wanted to accomplish and was having success in achieving her goals, however at times she was frustrated because she felt that she was ineffective. In the baseline data, Tracy spoke about some of the times that she felt ineffective which she described as fearful and scary. Tracy expected her students to do well and she was very concerned about being able to help students who had difficulties in her class. This concern was reflected when Tracy spoke about students that were struggling when she said,

I guess I live in fear and I think a lot of teachers do of not being able to anticipate how to help a student who may be stuck in that present a problem phase and that's stressful (TLPI y0).

Tracy believed that she could motivate all students to learn and she used different strategies to motivate them and encourage them to show their originality and creativity. Tracy believed that she could sometimes have an impact on the factors that motivated students, however sometimes her efforts were not successful in influencing the motivation of some students as acknowledged by Tracy in this statement,

There are times when I know that I have not changed their attitude. They've come in and they say, "I've hated science," and they leave thinking "I've hated science" (TPPI y0).

This sentiment is also reflected in the TLPI y0 interview when Tracy described some students' lack of engagement and motivation as scary:

I think the scariest thing for me is probably the same thing that a comedian feels on stage is when people are apathetic, they're not with you anymore (TLPI y0).

In February of the second semester of the second academic year of the study, Tracy stated,

Do you guys remember that graphic and I found it offensive at the time and I don't know if I still do or now, but the day that Bill Leonard came in with the picture of the funnel and the stick boy. That's what we're talking about. I think... The funnel and ear and the funnel and you turned it over, the funnel and the puddle on the floor. I left that class thinking "you idiot", but then it really hits one of the frustrations I think that we all feel. I feel ineffective sometimes and that's really what it's getting to. Thirty-five minutes of "What?" You know what I mean? (AR y2s5)

Tracy was voicing her frustration at what she perceived as her being ineffective. When she first saw the graphic used in the PD, Tracy was offended initially because it is very difficult for teachers to confront what they have been doing for years and what they feel that they have mastered and admit that it was inadequate (Levin & Wadmany, 2007).

Tracy sometimes felt ineffective because despite her best efforts to fully engage all students and to help them expand their cognitive capacity which she strived to do, this was evasive.

The data indicated that Tracy knew what she wanted her students to do and had strong beliefs about their roles as proactive learners. She had some success with this goal but often could not specify exactly how she was doing it. Tracy was not always consciously aware of how she facilitated her students' development as proactive learners. After the first year of the study, Tracy acknowledged that TEFA had resulted in her being more successful in achieving her goal of helping students develop as proactive learners and in giving her insights on what was working, what was not working and the reasons why.

## **7. Early Success with TEFA**

Tracy had some early successes with TEFA that were consistent with her expectations. This sold the TEFA pedagogy to her as something that could fulfill the goals she had for herself and her students. Her students loved the interactivity of the personal response system (PRS), or “clickers” as they are commonly called, which is the technology used to facilitate the TEFA pedagogy. Tracy explained, “It was great! Many students were willing to share what their choices were ...and explain their reasoning” (Journal 9/24/06). In the TVBI interview (second semester of first year) Tracy said that,

My initial experience with TEFA was positive. By positive, I mean I heard more from students than I had in the past about what they were actually thinking. It hasn't always been perfect, but I like the fact that kids are willing to defend choices in the context of using the clickers. And in the way, that's really what science is supposed to be promoting (TVBI y1r1).

During the same TVBI interview after viewing a video clip of one of her classes, Tracy spoke about her love of TEFA because it was instrumental in her discovering the misconceptions the students had about atoms as indicated in this statement,

This was another class where I discovered that the way students perceive atoms- at least some of the kids in this class-nuclear charge is divided up in chunks that can pull - but once it pulls on one electron, it's giving up some of its energy and it only has a little bit less left to give to the next one and the next one. So their idea was that the more electrons it had for the nucleus to take care of...the less the charge each individual electron would feel. That was really an eye-opener for me. So we ended up, the following day, talking about satellites and, you know if you put lots and lots of satellites up...This was a day that I loved TEFA because I would never ever have heard [student] say that. And I - you know, how many years have there been kids sitting in my class thinking that, and I never knew it (TVBI y1r1).

Tracy also mentioned her early success with TEFA in the TPPI interview that was done in May at the end of the first year when she stated,

I got lucky. I think in the Fall. The group that I started using TEFA with had no problems technologically, I didn't have any technology problems like some other people in the class and my students liked using it (TPPI y1r1).

Tracy experienced early success with TEFA which led her to embrace TEFA and PRS. From the first time that Tracy introduced it to her students, it helped her to address the need of challenging students and helping them to develop as engaged and proactive learners.

### **G. Conclusion**

Analysis of the data revealed that there were factors that were precursors of change in Tracy's adoption of TEFA pedagogy. Tracy's confidence and competence as a chemistry teacher, her self reflection, her willingness to be assessed by others, her need for variety in her teaching and her learning style were factors that were pivotal in

her facility of TEFA. Tracy's expectations for TEFA professional development also influenced her receptiveness to learn and adopt TEFA. Additionally, her expectations for her students to be proactive learners in the role of advocates and the early success she experienced with TEFA also emerged as strong determinants in her facility of TEFA. In Section H, I will discuss the impact of the School Situated Sustained Professional Development Model that was implemented at Tracy's school and that facilitated her learning and integration of TEFA.

#### **H. Impact of SSSPD**

In Section H, the data is examined to provide answers to the third secondary question, How does the SSSPD model affect the participant's practice while implementing the TEFA pedagogy? I will discuss the effect that the Sustained School Situated Professional Development (SSSPD) model, used to teach and provide support for the TEFA pedagogy, had on the evolution of Tracy's practice. Findings from the data will be used to answer the secondary research question: How does the School Situated Sustained Professional Development (SSSPD) model affect the participant's practice while she learned and integrated the TEFA pedagogy? The results revealed that Tracy believed that the SSSPD model may have had a positive impact on the evolution of her practice. It appears that Tracy benefited from the technical support of the university faculty and from the collaborative, collegial interaction of her peers afforded by the regularly scheduled meetings of the SSSPD. The meetings were held weekly during the first year and sustained monthly during the second year.

The results are given using Tracy's own words as much as possible to illuminate her perceptions of TEFA and PRS and how she was using them, the experiences that she

had with the TEFA pedagogy, what she was using the new pedagogy for and the changes that occurred in her practice. The specific references that Tracy made about the influence of the SSSPD model on the changes that she experienced will be highlighted in comments that she made during interviews, PD sessions and in classroom observations. This approach is being taken so that you could “hear” Tracy’s voice about the role that the SSSPD model had on her learning and integrating TEFA pedagogy into her teaching. Tracy’s voice is a powerful tool that gives credence to the impact of the SSSPD model in her own words. Excerpts from numerous data sources will be used to validate and triangulate the influences of the SSSPD as perceived by Tracy.

### **1. SSSPD model**

One of the purposes of this research was to study a teacher learning of new pedagogy while she is participated in Sustained School Situated Professional Development (SSSPD) by examining what was happening in the TEFA project that was utilizing SSSPD for the two year duration of this project. SSSPD was a structured professional development model that was situated at the school campus where Tracy taught and that was sustained with a series of regular meetings.

The SSSPD model being situated onsite at the school in the familiar environment where Tracy practiced was beneficial and may have been a factor in her being able to attend nearly every session for the two years of the study. Many times Tracy had meetings to assist students after school or other things that she attended to after school before coming to the sessions. Having students come after school was one way that Tracy provided assistance for students who were having challenges. During the first year after coming a few minutes late for one of the action research sessions,

Tracy commented that it was “so convenient that this [*the PD*] is right at school” and that she was able to work with her students after school and still come to the PD (Researcher’s notes).

## **2. Effects of the SSSPD**

Tracy learned how to use PRS to implement the new TEFA pedagogy in the regularly scheduled PD sessions. Statements that Tracy made in the data suggest that the support she was given facilitated her implementation of TEFA. The data showed that Tracy believed that the PD sessions and the support given in the SSSPD had a impact not only changing her practice, but on sustaining the changes that Tracy made in her practice. It is important to validate what the data revealed about the positive impact that the SSSPD model had on the evolution of Tracy’s practice with as many data sources as possible. Validation of theories is important to ensure credibility and a good way of validating theories is through member checks. (Strauss & Corbin, 1998; Merriam, 1992; Miles and Huberman, 1994). Keeping this in mind, I sent Tracy an email and asked her three questions about her thoughts about the effects that the long term SSSPD had on her practice. My questions and Tracy’s responses to the email are included below and serve to further verify some of the benefits that the findings have revealed about the SSSPD model.

Excerpt from Email - Tracy’s Responses from Email are in italics.

1. What changes did you experience as a teacher and as a person, in your teaching and in your views about teaching and learning as a result of your participation in the TEFA project?

*As a teacher my participation in TEFA has given me a better sense of how to plan for my students. Assessing what students already know and probing for misconceptions with TEFA style questions has informed my lesson planning.*

2. How did the TEFA PD course and action research regularly scheduled weekly and monthly (2nd year) sessions held at your school impact/influence the changes that you have identified?

*Having regularly scheduled TEFA sessions at our school reminded me to plan to use PRS. Change is a slow process. I needed to remind myself that I really had intended to incorporate new teaching strategies into my lesson plans. Knowing that we would meet to discuss our "research" was a good motivator for me.*

3. Would the effects of the TEFA PD model have been the same if the PD did not have regularly scheduled sessions that were continuous for two years on site at your school? Why/Why not?

*For me, the effects of the TEFA PD model would not have been the same if we had not met regularly, because regular meetings encouraged me to assess my "research" and to discuss what was working (and not working).*

In the email script above, Tracy wrote about some of the benefits of the SSSPD which included using formative assessment to guide her planning, serving as a reminder and motivator for her to use TEFA. The regularly scheduled meetings served as an impetus for Tracy to incorporate TEFA into her lessons and helped her to “assess” herself and her practice as she discussed what was working and what was not working with her peers and the facilitators in the regularly scheduled PD course. The data from the seven sources that were analyzed for this study showed that Tracy reflecting on her practice,

assessing herself and the successes and challenges that she was having with TEFA, and her interaction with the faculty facilitators and her colleagues were continuous throughout the two years of this study.

The SSSPD was designed and implemented to facilitate and sustain the learning of TEFA, and as such both the SSSPD and the pedagogy are intricately interwoven in the process of teacher change experienced by Tracy. In addition to the benefits outlined in the email above, there were many other benefits that Tracy attributed to TEFA and to the SSSPD that will be highlighted in this section. Tracy's comments about different aspects of TEFA pedagogy and about the impact that the TEFA PD had on her and on her practice will also be discussed. Tracy perceived TEFA through the lens of her way of being as a teacher. One perception that Tracy had of the TEFA pedagogy was that it had the rigidity of rules. She believed that when she did not implement TEFA the way it was presented in the PD course that she "broke the rules" (TLPI y1r1). Another way that Tracy interpreted TEFA is reflected in her next comments. "Because in the philosophy of - at least the way I'm interpreting this pedagogy is supposed to work, is that the teacher is really not supposed to be the front: the ultimate this is right, this is wrong" (TLPI y1r1). Tracy's beliefs and perspectives about TEFA and the PD influenced how she used TEFA.

**a. Personal Interactions**

The frequent and continuous personal interactions that Tracy had with the university faculty facilitating TEFA and the guidance and support that they provided for the duration of the study emerged as major factors in the changes in Tracy's practice and

in the sustainability of those changes. Tracy frequently mentioned Bill Leonard, the university faculty who was the main facilitator of the PD course. She mentioned other faculty less frequently. The data suggests that the frequent interactions that Tracy had with faculty had an impact on her and on her practice. Throughout the data sources used for this study, Tracy spoke about the different topics that were taught during the professional development course and that were discussed in action research. Tracy liked the way that Bill facilitated the course and spoke about his role in helping her to learn TEFA. The following excerpt illuminates Tracy's perceptions of some of Bill's qualities as a facilitator, some of her personality traits of liking the opportunity of being a student, of being assessed and of reflecting on her practice and assessing herself.

Going on record. I like Bill. I think he's a good teacher. I think his intentions are good and he treats us as if it's possible for us to learn what it is that he wants to teach us. So it's good for me to sit in the student chair in that regard (TVBI y1r1).

Tracy spoke about Bill's role in helping her define the type of personality she had at the beginning of the TEFA project and what was one of her primary foci at that time in this second excerpt;

So to answer your question (*about change in discourse pattern in second video*), ultimately, because Bill Leonard told and I'm type A personality, in the beginning of trying TEFA, I intentionally tried to not to...assess what was said. I wanted to try to be as neutral as I possibly could and it paid off for me to not say (TVBI y1r1).

In next excerpt, Tracy speaks about TEFA promoting more student-to-student communication during discussion.

I think the intent of the PRS instruction was to get us to think about how we could hear more student discussion with other students and people challenging other students ideas, which I think is something I'm taking away from this class that's very good (TPPI y1r1).

The two previous excerpts were about different skills in conducting and managing WCD. They were chosen because Tracy spoke about how she benefited from the course and they are representative of how Tracy dissected the TEFA pedagogy with regard to WCD into manageable chunks that she modified, refined, personalized and translated into skills individually architected to support her goals. Tracy decided which aspects of TEFA she wanted to focus on throughout the study. Tracy continuously tried new things and evaluated their effectiveness, she depended on the feedback and support of Bill, other faculty, her colleagues and her students which she considered as she made further adaptations and changes to her practice.

There were many components of the TEFA pedagogy that were taught throughout the first year. Only a few of them will be highlighted in this section. Many other strategies have already been discussed earlier in this chapter which included integrating TEFA into her teaching style, question writing, managing whole class discussion and uses of TEFA and PRS. Data that was analyzed suggest that Tracy worked at learning aspects of TEFA pedagogy that were introduced during different PD sessions of the study and needed more than one session to learn and implement the strategy. Bill used the same strategies with the teachers who were participating in the TEFA project that he wanted them to use with their students in an effort to give them hands-on practice with the new strategies. In the statement below, Tracy spoke about the tension she was experiencing with not giving students the correct answer during the first action research session;

I am driven personally to give the correct answer at the end and how I'm going to have to fight doing that when Bill Leonard hasn't given us the answer (AR y1s1).

Tracy was trying to reconcile what Bill was modeling about not telling students the answers with her style of teaching and was experiencing some tension while doing so which she expressed as having to “fight”.

**b. Modeling Students**

Modeling students helps the teacher to continuously adapt instruction to meet students’ needs. There are various ways that teachers could model students that include: 1) gauging and monitoring students’ understanding, 2) probing to assess students’ understanding and preconceptions, 3) allowing students time to process information and think deeply instead of giving them answers to questions, 4) focusing on students’ need to ask questions rather than on providing an answer, 5) focusing on understanding why students provide answers for questions rather than on whether they are correct, 6) encouraging students to use the scientific method: observe, model, predict, test, refine, and 7) encouraging input from other students to help understand a particular student's difficulty (Beatty, 2006).

Although Bill was demonstrating modeling as a strategy with the first PD course, in second action research session nearly two months later Tracy was still asking, "How to model students? I don't know what that means, "to model students" (AR y1s2). In her video taped lessons later in the first year and the other lessons video taped during the study Tracy showed that she had learned how to model students and was using that as one of the main strategies in her classes. The following excerpt from Tracy’s video taped classroom observation in Spring of the second year, reflects one of the ways that Tracy modeled students;

Excerpt from TCOP y2r3.

Tracy: *[after displaying the histogram]* So, fourteen of the fifteen people said that they believe the mass is the dependent variable and then one person, which I am guessing is you Gary.

*[inaudible response]*

Tracy: What? Did you get your two letters? I just missed it. Oh, you didn't get to enter at all, so there is somebody else who entered 'W' and 'M'. Who is that brave soul? Cory, why?

Cory: I thought, like, I know the mass depends on the amount of sucrose in there, but also the amount of water that goes into the tubing, it depends on the amount of sucrose already there.

Tracy: I think that's a really clever-- Probably the best answer because, yeah, the mass changes, but he is thinking about why the mass changed and that is because of the movement of water. So, oh-- I was expecting 'M', but I like 'WM' better. I think that is a great answer

In the previous excerpt, Tracy asked Cory his reason for choosing his answer. After Cory explained his reasoning, Tracy considered Cory's understanding and his conceptions that led to his answer. Even though she had another answer in mind, Tracy accepted Cory's answer because she was focusing on understanding his reasoning behind the answer rather than on whether the answer was what she anticipated. Tracy explored Cory's thinking as indicated when she said, "but he is thinking about why the mass changed and that is because of the movement of water". Tracy then adapted her thoughts about the answer that Cory gave and continued to guide the class based on what Cory said. Even though Tracy was exposed to modeling students at the beginning of the year and in consecutive PD courses, the data suggests that it was several months before she was comfortable with using modeling as a strategy in her classes.

### **c. Impact of SSSPD Strategies**

Having participants view their video taped lessons was another strategy that was used in the professional development model. During the first year in the professional development course, the participants were asked for their permission to show clips of

their lessons. Segments of lessons of different participants were chosen by faculty facilitators that showed a cross section of various uses of PRS and TEFA, teaching styles, interactions with students, classroom dynamics and other factors with regard to TEFA pedagogy implementation. During the same year, each participant was given their video taped lessons on CD and asked to view the lessons, choose a five minute segment that they would like to share with the group and be prepared to share something they observed at the next action research session. The format of the collaborative sharing was informal and the participants were given some examples of what they could share which included: specific areas of TEFA and PRS that they wanted feedback on, new discoveries they made about themselves as teachers or about anything pertaining to their practice and ways that they had modified TEFA.

The teachers also viewed five minute video clips of the two video-taped lessons, one from baseline and one from the first year during the TEFA Video Based interview (TVBI) where they commented on the changes that they observed from the baseline video to the year one lesson that was video taped. So there were three formalized opportunities for teachers participating in the TEFA project to view their videotaped lessons and they had their lessons on CD's to view whenever they liked. In the following excerpt, Tracy comments on the realizations she made about her practice after watching the video.

But I would definitely say that my intent for a whole class discussion is to start it, be the leader in the beginning, and then step sort of to the side and be more of a facilitator. But I still feel like, having watched myself in the videos, that I'm channeling, that I'm the bank, I mean the river's flowing but I'm saying "You're going here!" So, yeah, I want to lead it to some sort of an end (TPPI y1r1).

One of the impacts that the SSSPD model had on changing Tracy's practice was that the strategy employed by the professional development of observing video taped lessons helped Tracy reflect on, analyze and self evaluate her practice. Watching herself teach, raised Tracy's self awareness of what she did in the classroom and gave her a frame of reference of what she needed to change. Through watching the videos, Tracy realized that her intentions and goals while delivering instruction were not always consistent with what she did during her lessons.

Another impact that the SSSPD model had on Tracy was her keeping a journal. At the beginning of the TEFA project, Tracy stated, "I have never been successful at keeping a journal" (AR y1s1). However, in the second year she was still keeping a journal and using it as a reflective tool although the journal entries fluctuated in frequency. Using a journal as a reflective tool was one of the changes that were influenced by TEFA PD model. In this regard, Tracy stated,

I also recognize, when we were writing in our journals - I recognized that there are qualities in me, as a student, that I definitely see and find annoying in my students... I recognize that it's an inquisitiveness and it's a need to be right. I mean, there are all these little features that--and I think, in one guy who I really liked, but who drove me crazy because he...he just was constantly in my face with what I need. Well, you know what? I do that all the time. And that's been a great experience too (TVBI y1r1).

As Tracy reflected on and analyzed her practice, she gained some insights of who she was as a teacher and about things that she did in her classroom that she was not conscious of before keeping a journal. The journal was an effective tool in helping Tracy further define who she was as a teacher and in illuminating aspects of her character and personality that she was not conscious of before.

#### **d. Flexibility of SSSPD**

The professional development (PD) course and action research sessions of the SSSPD model were sessions that were structured with some flexibility. There was a fluid agenda that was influenced by feedback from the participants and was adjusted in response to participants' suggestions and needs. The participants' verbal feedback during the sessions was used in addition to feedback from their daily logs and monthly reflection surveys to guide what was done in the PD course and action research session. The characteristic fluidity of SSSPD and its adaptability based on the needs of the participants helped Tracy learn TEFA pedagogy. Another strength of SSSPD was that it provided prescriptive and frequent feedback which assisted her to assess and modify what she was doing in the classroom.

Tracy voiced her appreciation in the monthly reflection survey for the way the PD was modified after feedback from the participants in the following statement;

Thank you for adjusting the style of the class. I like having focused question styles to work on, that we try in our classes, and then discuss during the following class. I also like having a couple transitions in the time that we meet after school...we talk, you pose a puzzle or two, we plan...it's good (TMR y1r5).

This use of participants' input to guide and modify the SSSPD model during its implementation to better meet the needs of the participants is another strength of the model.

The regular scheduled sessions seemed to be instrumental in allowing the facilitators to make continuous and prescriptive adjustments as participants tried new things with the TEFA pedagogy in their classes. Tracy also benefited from the

collaborative expertise and experience of the other participants and valued the interactions with and input of her colleagues in assisting her to make changes in her practice as she integrated the new pedagogy. Tracy's thoughts about this collaborative sharing of ideas and exchange of information are reflected in the following excerpt. The excerpt is Tracy's response to a question asked by the researcher about the changes that were observed in her classes with regard to her eliciting students thinking more than she had done in the past.

*It's (stepping back to let students wrestle with concepts they found challenging and not jumping in to give them the answers) evolved over time. But I will honestly say that some of the conversations that we've had on Monday afternoons helped, just listening to other people talk about what they're doing in their classes and also listening to comments about learning in general and reflecting on ...what I would like people to really retain (TLPI y1r2).*

Tracy acknowledged the input and contribution of discussions and interactions in the weekly PD in helping her to change some of the things that she did in the classroom.

## **I. Conclusion**

The data showed that although Tracy emerged as an exemplar of TEFA pedagogy integration when compared to the other nine participants in the study, she had to have more than one session showing how a new strategy is used before she felt comfortable enough to use it in her practice. The data also suggest that the regularity of the PD sessions and the consistent support given by the faculty and her colleagues helped Tracy to adapt new strategies that were taught in the PD and internalize them to become a natural part of her practice. The data also showed that Tracy benefitted from the frequent collaboration with her peers who were also participating in the TEFA project.

## **J. Models of Teacher Change**

In the final section – Section J, the fourth secondary research question will be answered. How could the findings be used to develop a model of teacher change? I will describe the process of constructing a model then I will look at three models of teacher change. I will discuss Shulman's (1986, 1987, 1990, 1992) Model of Pedagogical Reasoning and Feldman's (1999) Model of Practical Conceptual Change. I chose Shulman's and Feldman's models of teacher change as possible ways to provide frameworks for what the data revealed about the changes in Tracy's practice and to get a better understanding of her change process. The Elements of Teacher Change in Adoption of Pedagogy (ETCAP) Model, which was developed from the findings in this study, will then be described. The Elements of Teacher Change in Adoption of Pedagogy Model will be described in relation to Beatty et al (2008) Co-evolution of Practice and Pedagogy Model which was discussed in Section B of this chapter. I will compare Shulman's and Feldman's model to the ETCAP model and explain why I considered them inadequate in providing an adequate representation of what the findings revealed about the changes in Tracy's practice. I will then show how the changes that occurred in Tracy's practice fit into the ETCAP model.

As teachers' practice evolves, change occurs in various areas including change in the teachers' beliefs, knowledge, skills and in their use of new pedagogy (Levin & Wadmany, 2007; King, 2007; Wood et al, 2005; Hokanson & Hooper, 2004; Haney, et al, 2003; Earle, 2002; Ertmer, 1999). Changes in teachers' practice as it evolves can be depicted in various ways. A good way to depict and track change in a teachers' practice is to develop a model or framework for the change. The model could either be

empirical or theoretical. A theoretical model of change is a hypothesized dynamic of change with suggested variables that may influence the change. I will dwell more on the empirical model because it is the type of model that was used to develop ETCAP.

The development of an empirical model should be guided by findings from data. In depth analysis of data is used to identify important phenomena, trace operational linkages over time and reveal patterns (Yin, 2003a, 2003b; Miles & Huberman, 1994; Strauss & Corbin, 1998). The phenomena are categorized by grouping factors that share commonalities and the categories are used to build a conceptual framework. These phenomena are further examined to tease out relationships and interrelationships, other linkages and patterns which then form the basis of theory formulation (Yin, 2003a, 2003b; Miles & Huberman, 1994) on which the model is grounded. As the findings are re-examined and further analyzed, the model is refined. Then additional data from other teachers who are learning and integrating new pedagogy are processed through the model to test the validity of the model, to measure the reliability of the indicators of change; to assess whether the model provides a true representation of the change process; and to see if the model provides a better understanding of the relationships in the change process (Miles & Huberman, 1994; Strauss & Corbin, 1998). It is anticipated that in future studies the model could be tested to assess its predictive capabilities in identifying and tracking changes of teachers learning new pedagogy in similar situations. Future studies could also assess the consistency of interpretation of the model.

## **1. Model of Pedagogical Reasoning**

Shulman's (1986, 1987, 1990, 1992) Model of Pedagogical Reasoning lists the processes of pedagogical reasoning and action. The purpose of the model was to get a better understanding of the decision making process of teachers that guide their use of pedagogy or their choice of strategies to teach a particular concept. This model looked at teachers' content knowledge in a classroom context, and gave insights on how to assess their pedagogical reasoning. In the Model of Pedagogical Reasoning and Action there are three categories in Shulman's representation of teaching which are: a) pedagogical content knowledge, b) deep knowledge of the content itself, and c) knowledge of the curriculum.

Shulman believed that pedagogical content knowledge is specific to content and that teachers' beliefs and pedagogical content knowledge are closely integrated. How beliefs influence pedagogy and content to create practical and powerful pedagogical content knowledge is demonstrated in the teachers' practice (Shulman, 1986, 1987, 1990, 1992).

There are different processes in Shulman's model that teachers go through as they make decisions about their practice. According to Shulman, teachers go through these processes starting at the comprehension level and normally progress to higher levels as they become more experienced, more skilled and more competent in the various aspects of teaching. Preservice and novice teachers have difficulty in proceeding from comprehension process to the instruction process of Shulman's model. Shulman's processes of pedagogical reasoning are: 1) comprehension;

2) transformation; 3) Instruction; 4) Evaluation; 5) Reflection; and 6) new comprehension.

### 1. Comprehension

Teachers develop an understanding of what they teach and an understanding of what they teach in a variety of ways.

### 2. Transformation

Teachers transform content knowledge into pedagogy that is adaptive to their students' needs. For transformation to occur, teachers go through the following processes:

Preparation – critical interpretation

Representation – of ideas in the form of analogies and figurative language like metaphors

Instructional selections – making selections from a repertoire of methods and models

Adaptation - to reflect students' characteristics and learning styles

Tailoring adaptations - to specific students' needs

### 3. Instruction

Instruction includes all aspects of pedagogy implementation eg classroom management and dynamics, strategies used, interaction with students.

### 4. Evaluation

Assessing students' understanding while teaching and at the end of lessons or units then using that assessment to evaluate and adjust their (teacher) performance.

### 5. Reflection

Reflecting on and analyzing themselves and identifying changes that need to occur in their practice.

#### 6. New comprehension

Teachers receive new comprehension, a better understanding of educational purposes, the subject/s taught, of the students and of the pedagogy.

### **2. Model of Practical Conceptual Change**

Feldman (1999) looked at teacher reasoning as a way of understanding teachers and teaching and to construct a model of practical conceptual change. Numerous decisions are made by teachers each day that are within the practical domain. Before change could occur in teachers' practice, they must accept new practical theories. Therefore, there needs to be a better understanding of teacher reasoning and their practical theories that influence their practice.

In order to construct a framework to get a better understanding of how and why teachers change their practical theories Feldman (1999) used the Conceptual Change Model of Posner, Strike, Hewson, & Gertzog (1982). Posner et al., (1982) listed four conditions that fostered conceptual change which are:

1. There must be dissatisfaction with existing conceptions
2. A new conception must be intelligible - for a learner to accommodate a new conception, she must find it intelligible.
3. A new conception must appear initially plausible - for the new conception to be accommodated, the learner needs to find it fruitful, beneficial and have the potential to open up new areas of inquiry.
4. A new concept should suggest the possibility of a fruitful research program.

Feldman (1999) suggest that teachers may accept new practical theories, consonant with reform, if they are discontent with their old practical theories and they find the new ones sensible, beneficial, and enlightening. These are conditions that lead to the accommodation of a new practical theory which are described below.

- 1 Discontentment with understanding of current practical theory because it is recognized as ineffective, unsuccessful, impractical or there is dissonance between the teacher's beliefs and her perceptions of what is wrong in her practice.
2. New practical theory must be sensible and comprehensible for it to be accommodated by the teacher.
3. The new practical theory must have beneficialness. This means that the new practical theory must lead to better actions or goals that make the teacher's practice more effective for it to be accommodated.
4. The new practical theory must be illuminating or enlightening to provide new understanding of practical situations. This new understanding can be used to modify the new practical theory to the particularities of different situations.

### **3. Elements of Teacher Change in Adoption of Pedagogy (ETCAP)**

The data revealed many insights about the process of change experienced by Tracy. These changes were initially examined using the Co-Evolution of Practice and Pedagogy Model (Beatty, et al, 2008) in Section B of Chapter 4. As I examined the data, I realized that I needed to look more closely at the Co-Evolution model as a teacher goes through the processes of states and change. Based on this realization, I developed the Elements of Teacher Change in Adoption of Pedagogy (ETCAP) model. The development of the ETCAP model was one of the major outcomes of this study.

The ETCAP model is grounded on the premise that learning a new pedagogy and changing teachers' practice is a multifaceted and complex process that involves all aspects of a teacher's practice including a teacher's beliefs and perspectives, content knowledge, pedagogical methods, classroom management skills and inter and intra personal skills.

The micro examination of the evolution of teacher change using the ETCAP model aimed to further illuminate the change process in the Beatty, et al (2008) model by teasing out the intricacies of the factors that may have a bearing on the evolution of change. The ETCAP model supports the Co-Evolution of Practice and Pedagogy Model and was developed out of a need to get a better understanding of the change that was occurring in Tracy's practice as outlined in Co-Evolution of Practice and Pedagogy Model and to explore those changes in finer detail. Therefore, the finer details of the changes that occurred in Tracy's practice are encapsulated in the ETCAP model. In other words, if you were to take one evolution cycle of a state and a change process from the Beatty's model what would it look like as a teacher's tensions and dissonance produce conflict, struggles and rewards which result in the process of change on a micro level?

The ETCAP model was developed using data from the seven qualitative and quantitative data sources including surveys, interviews, classroom observations and journal entries that were used for this study. The processes that Tracy experienced were instrumental in developing the ETCAP model. Only Tracy's data was examined using the ETCAP model because she was the sole participant of this study. However, the development of the ETCAP model was based on data from four other participants in the

larger TEFA project to test its validity and viability as a credible model of change in Tracy's practice.

Directed by the primary and secondary research questions, data were initially coded to distinguish broad categories and then analyzed. The initial coding and analysis were used to refine the coding scheme and guide further analysis and further develop the patterns. Cross-case analysis and analytical comparisons were done using the various data sources to explore linkages, relationships and interrelationships between the five participants that were used to develop the ETCAP model. Connections and relationships were identified and emergent themes and patterns in regard to change in the participants' practice were used to construct the ETCAP model. Additional data were then processed through the ETCAP model to test whether the model was representative of the changes in Tracy and the other four TEFA participants' practice that were revealed in the data. The elements of change that emerged from the data and that were used to develop the ETCAP model were triangulated with at least three sources of data. The researcher analyzed the data of other participants as part of her responsibilities as a Research Assistant for the TEFA project.

The findings show that there are eight elements of change that teachers experience as they learn and adopt new pedagogy. I have labeled these Elements of Teacher Change in Adoption of Pedagogy (ETCAP). Each of the eight elements has distinctive characteristics that have bearing on the change process. The eight elements are in three categories which are: a) Way of Being, b) Tensions & Dissonance, and 3) Simulation and Application. The elements of the ETCAP are: 1) Sense of Self, 2) Perception of Pedagogy, 3) Process in Personal Context, 4) Reconciliation with Way of

Being, 5) Translation, 6) Trial and Evaluation, 7) Simulation and Application, and 8) Innovation. Table 2 below shows the categories and the eight elements of teacher change. Figure 5 on page 201 shows a graphical representation of the ETCAP model.

**Table 2: Elements of Teacher Change in Adoption of Pedagogy (ETCAP)**

<b>Categories</b>	<b>Elements of change</b>
a) Way of Being	1. Sense of Self 2. Perception of Pedagogy 3. Process in Personal Context
b) Tensions & Dissonance	4. Reconciliation with Way of Being 5. Translation 6. Trial and Evaluation
c) Simulation and Application	7. Simulation and Application 8. Innovation

Different teachers may experience the elements and the processes of the ETCAP model in different ways. Some teachers' experience of ETCAP may be a step-by-step process. Other teachers' experiences with the ETCAP model may not be so sequential. The elements of change are interchangeable as teachers may alternate between different elements. Therefore, a teacher may not experience the various elements of the ETCAP model in sequence starting with the first element and moving through each element in turn. The teacher may loop back to previous elements, re-evaluate and modify his or her practice before moving through the other elements. The teacher may also skip elements as she learn and integrate new pedagogy. How teachers experience the elements of change depends on the individual teacher and on factors that influence their practice including their experience, their competence, their goals and their expectations for the new pedagogy. I will now describe the elements of change as outlined in the ETCAP model on page 201.

**a. Sense of Self**

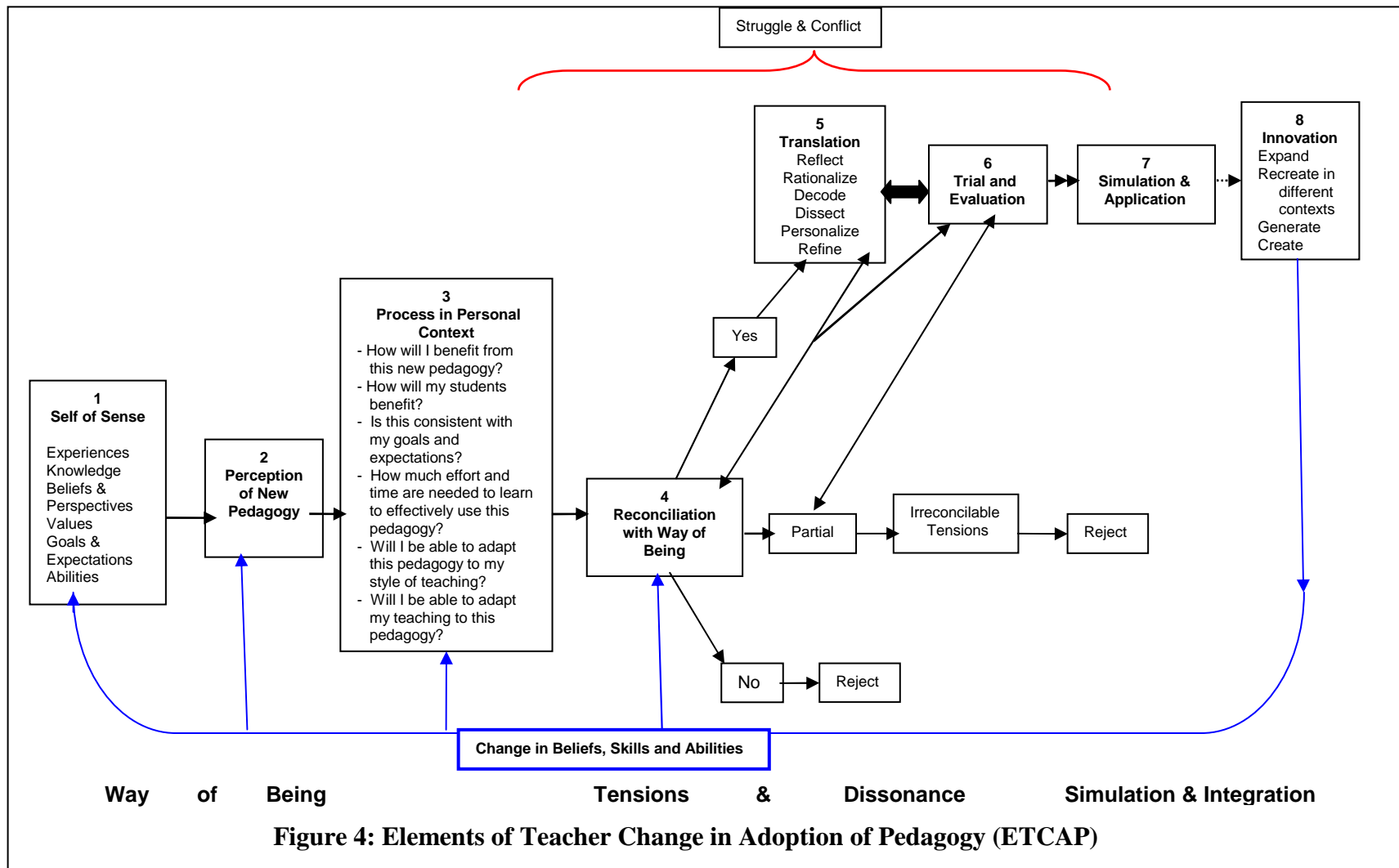
In phase 1 of the micro processes of pedagogy integration, the teachers come to the professional development with their sense of self and their way of being as teachers already defined. The factors that are influential in shaping the teachers sense of self are their experiences, knowledge, values, beliefs and perspectives, their goals and expectations, their abilities, their professional, social and personal interactions and their relationships (Feldman, 2002).

**b. Perception of Pedagogy**

In phase 2 after being exposed to the new pedagogy teachers develop their individual perceptions of the pedagogy. The teachers' perception may or may not align with the pedagogy as represented in the professional development. There may be dissonance between the way the new pedagogy was represented in the professional development and what the teachers perceive as the expectations of the PD facilitators (Beatty, et al., 2008).

**c. Process in Personal Context**

The third phase is a self analysis phase in which teachers process the new pedagogy in their personal context and in light of their beliefs and values by identifying main aspects of their practice and examining them in light of their perceptions of the new pedagogy. The teachers' analysis of what they perceive about the new pedagogy may include them answering questions similar to: 1) How will I benefit from this new pedagogy? 2) How will my students benefit? 3) Is this consistent with my goals and



expectations? 4) How much effort and time are needed to learn to use this pedagogy effectively? 5) Will I be able to adapt this pedagogy to my style of teaching? 6) Will I be able to adapt my teaching to this pedagogy?

**d. Reconciliation with Way of Being**

The answers to the questions in phase 3 dictate whether the teachers will reconcile their way of being and what they do in the classroom with learning and integrating the new pedagogy into their practice or whether they will reject it. Tension begins as teachers confront their way of being and try to justify why they should change. If most of the responses to the questions are positive, the teachers most likely feel that the new pedagogy could be reconciled with their way of being. The teachers' perception of the new pedagogy may be wholly or partially reconciled to their way of being or may not be reconciled at all. If the teachers completely or partially reconcile the new pedagogy to their way of being, then they enter the translation phase. Teachers who partially reconcile the new pedagogy may proceed directly to the Trial and Evaluation Phase and after not having the success that they expected, may decide that the new pedagogy cannot be reconciled with what they believe and what they do as teachers. If they do not reconcile the pedagogy, they will reject it.

**e. Translation**

In the Translation phase the teachers explore their use and their students' reception the new pedagogy. The teachers rationalize their use of the pedagogy in light of their goals and expectations. They decode the new pedagogy translating it from the technical terminology or what the teacher may construe as theoretical rigidity in the way that the pedagogy is represented in the professional development into more user friendly

vernacular. The teacher may then dissect the pedagogy into manageable chunks and prioritize which aspects of the pedagogy may be most useful or most easy for them to try. The teacher may then personalize and refine the pedagogy to suit his or her needs and the needs of their students or the teacher may transform the pedagogy into something that is completely different from how it was presented. Then they may start slowly and cautiously to try parts of the new pedagogy.

**f. Trial and Evaluation**

The Translation element is followed by Trial and Evaluation. In the Trial and Evaluation phase, the teachers try the new pedagogy and then evaluate its success similarity to the way they evaluate a lesson. In some instances, a teacher may bypass all the other elements and decide to try the new pedagogy in their personal context. In processing the relevance and effectiveness of the new pedagogy, they may ask themselves questions like: 1) Did this pedagogy help me achieve my goals? 2) Were my students responsive to the new pedagogy? 3) Is learning or using this new pedagogy an efficient use of my time? 4) Am I becoming more confident and competent using the new pedagogy? 5) What do I need to become more confident and competent with the new pedagogy? 6) Can the pedagogy become an integral part of my practice?

During Trial and Evaluation process, the teacher may lapse back into her old way of teaching, which is her comfort zone. Going back to the old way of teaching occurs less frequently as the teacher's tensions and conflicts are resolved and the teacher experiences more success with using the new pedagogy. The teacher may alternate between the Translation and Trial and the Evaluation phases for several pursuant cycles

as primary conflicts and struggles may give way to secondary ones and they try out different ways of using the new pedagogy to resolve these struggles and conflicts (Beatty, et al, 2008). The struggles and conflicts are constraints and barriers that may inhibit integration of the new pedagogy. If the constraints and barriers are resolved, the teachers adopt the new pedagogy as it is represented in the professional development or adapt it based on their needs and the needs of their students. Full scale adoption of a new pedagogy just as it is presented in PD is very rare, if existent at all. Conflicts and struggles may include the teachers feeling that the new pedagogy is stylistically opposed to their mode of teaching, teachers' lack of confidence or lack of competence in using technology, lack of equipment and/or resources that accompany the new pedagogy, unreliability of equipment, lack of administrative support, curricular and school demands, time constraints and personal issues (Beatty, et al, 2008; Ertmer, 1999; Earle, 2002; Hokanson & Hooper, 2004; Wood et al, 2005).

During the Translation and Trial and Evaluation phases, the teacher makes most of the changes to his or her practice. The process of the change may be a series of steps taken that are very obvious and deliberately architected by the teacher or it could be subconsciously done.

#### **g. Simulation and Application**

The seventh element is Simulation and Application. In this phase, the new pedagogy is integrated into the teachers' practice based on their and their students' perceived needs. The teacher finds a niche where they feel that the new technology is used most advantageously or in a way that could be of the most benefit. Simulation and Application are often preceded by a shift in the teacher's thinking and a change in the

teachers' beliefs. The teacher's development of a better understanding of the viability of the new pedagogy in improving her practice is instrumental in uprooting embedded practices which make it easier for the teacher to simulate, apply and integrate the new pedagogy into her practice. In this phase, the new pedagogy is internalized and becomes a natural part of the teacher's practice.

#### **h. Innovation**

The eighth and final element of the evolution of teacher change is Innovation. In this phase, the teacher expands on the pedagogy, generates or creates new innovative ways to use the pedagogy and/or recreates the pedagogy in different contexts. The Innovation phase depends on how adept the teacher is, on the teacher's aptitude, experience and competence. Therefore, not every teacher may reach the Innovation phase when integrating new pedagogy into their practice - or if they do, it may take a longer time for them to reach this phase than some of their colleagues.

As a teacher goes through the different elements of pedagogy integration as espoused in the ETCAP model, there could be a rapid progression or slower more gradual movement through the stages. At first glance, the rapid progression may look like one fluid movement of facility but under careful scrutiny it often reveals a number of conflated processes giving the appearance of just one process. I will now compare Shulman's and Feldman's models with ETCAP.

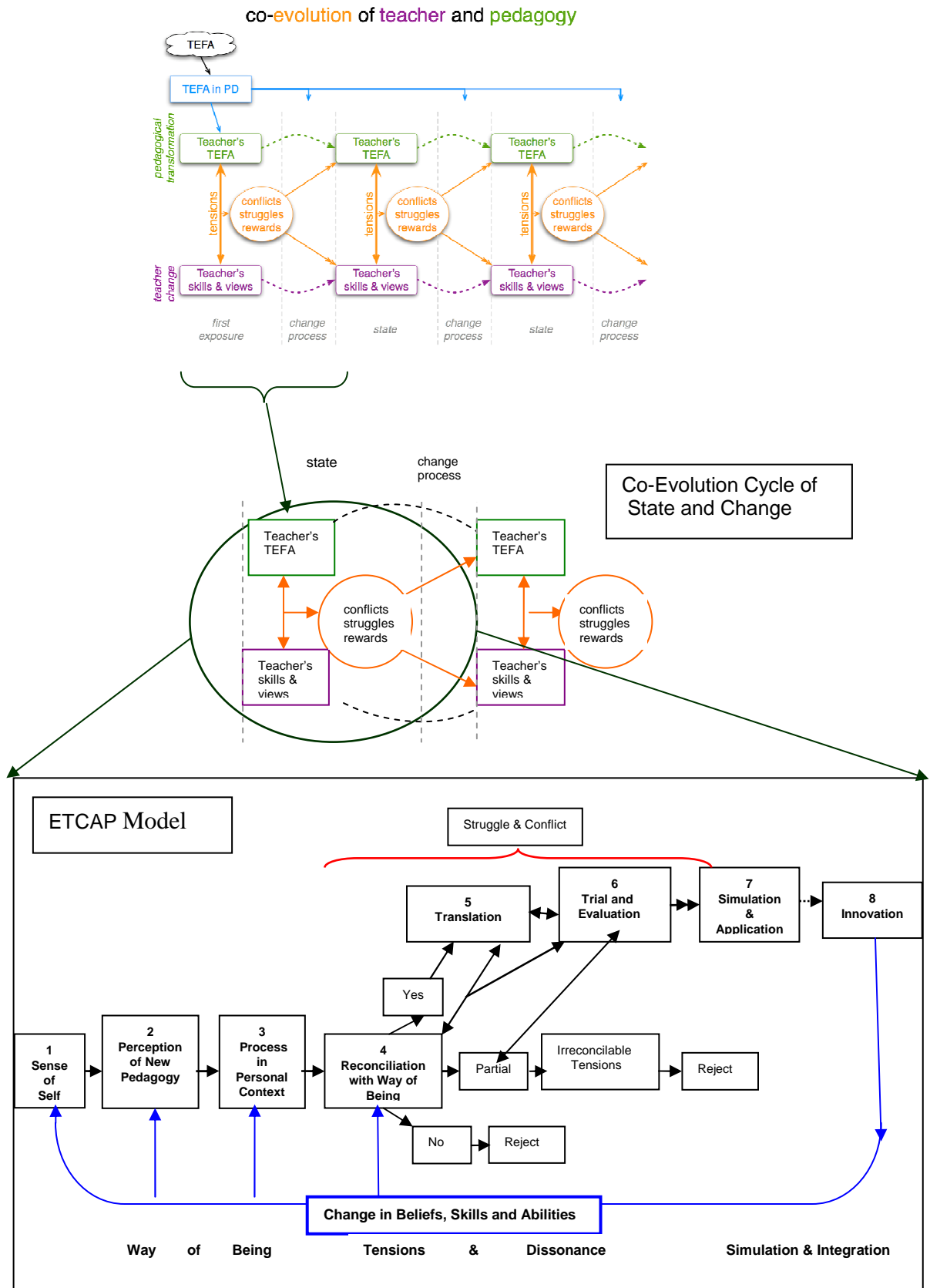
### **4. Linking ETCAP with the Co-Evolution Model**

How does the ETCAP model build on the Beatty, et al., (2008) Co-Evolution Model? The ETCAP model represents one cycle of the state and change process of the Co-Evolution Model. The first element in the ETCAP model, Sense of Self, reflects

teachers' skills and views in the Co-Evolution model. The second element in ETCAP, Perception of New Pedagogy, is representative of Teacher's TEFA in the Co-Evolution model as teachers develop their perception of TEFA, which may be different from the way it was presented in the PD course. The third element in the ETCAP model, Process in Personal Context, could be described as a secondary process of Teacher's TEFA on the Co-Evolution model, which is continuous as teachers use their perception of the new pedagogy to process it in their personal context. The fourth element, Reconciliation with Way of Being, of the ETCAP model could be equated with the line of tension on the Co-Evolution Model, which gives way to the conflicts, struggles and rewards. Phases five to eight in the ETCAP model, the Translation, Trial and Evaluation, Simulation and Application and Innovation phases are reflective of the conflicts, struggles and rewards on the Co-Evolution model. Figure 5 on the next page shows one cycle of the state and change process of Beatty et al., (2008) Co-Evolution of Practice and Pedagogy Model that is linked with and examined in more detail in the ETCAP model.

### **5. Comparison of Models of Teacher Change**

When comparing Shulman's Model of Pedagogical Reasoning and Feldman's Model of Practical Conceptual Change with the Stages of Teacher change in Adoption of Pedagogy Model (ETCAP), the following observations were made. Shulman's model is composed of processes of pedagogical reasoning which teachers go through as they make decisions about which pedagogies and strategies to use to teach different concepts. The ETCAP model is composed of elements of pedagogy adoption that teachers go through as they are learning a new pedagogy which encompass more



**Figure 5: Linking ETCAP with the Co-Evolution Model**

than the decision making processes. The ETCAP model takes a more in depth look at teachers' reorientation when adopting new pedagogy and the processes that they go through as they learn and adopt new pedagogy, reflect on and analyze their practice and redefine who they are as teachers.

In Shulman's model, teachers may pass through the processes in a relatively short time when compared to the time needed to learn and adopt a new pedagogy as outlined in the ETCAP model. A teacher could go through Shulman's processes during the time it takes to teach a unit or even in less time. Teachers may take months to pass through the elements of ETCAP and it may be at least a year before they become confident in using the new pedagogy. Some of the processes in the ETCAP model may continue after learning and integrating the new pedagogy. Feldman's model of Practical Conceptual Change gives credence to the ETCAP model as a way to understand why and how teachers go from elements two to four of the ETCAP model, which are the Perception of Pedagogy, the Process in Personal Context and the Reconciliation with Way of Being phases. Teachers' perception of the new pedagogy, their processing the pedagogy in their personal context and their reconciliation of the new pedagogy with their way of being are phases in which teachers evaluate and accept or reject new practical theories.

Shulman's model gives focus to pedagogical content knowledge, what teachers teach, how they teach it and their pedagogical reasoning that affect the decisions that they make about the way that they teach. Feldman's model gives focus to practical theory formation and how the teacher's practical theory is changed and new practical theory accommodated by the teacher. The ETCAP model includes the main

components of Shulman's and Feldman's models but is more holistic in including other aspects of the teacher's practice. These aspects of the ETCAP model include the foundational element of a teacher's sense of self (Feldman, 2000). The first stage of ETCAP explores the teacher's sense of self which includes their experiences, knowledge, beliefs and perspectives, their goals and expectations, their abilities, their professional, social and personal interactions and their relationships that strongly influence and guide the teacher's practice. Sense of self not only characterizes who the teacher is, but is the lens through which the teacher perceives the new pedagogy and provides the springboard for the learning and adoption of the new pedagogy, or becomes the obstacle that results in the teacher rejecting the new pedagogy. Although these factors are woven into some processes and conditions of the other two models, they are not in distinct categories as a frame of reference and a point of self reflection as teachers continuously evaluate themselves and their practice as they learn and use new pedagogy.

The similarities of the three models include processes of reflection, trying out new things, evaluating, adapting and refining and keeping parts of the new pedagogy or theory that are practical and beneficial. All three of the models have a process of creating something new, or having new comprehension or using the theory in many different contexts. One of the main differences between the three models of teacher change is that Shulman's model gives focus to pedagogical reasoning in choosing different pedagogies to teach concepts, Feldman's model deals with changing teachers practical theories while the ETCAP model encompasses pedagogical reasoning in making choices, teachers' practical theories and other processes that the teacher goes through as she redefines and reinvents herself as a teacher. These other processes

include the teacher assessing and modifying his or her perspectives and belief systems. It was felt that since Shulman's model only dealt with pedagogical reasoning and since Feldman's model only dealt with practical theories, another model was needed that encompassed both of these critical areas and other processes that the teacher goes through, hence the ETCAP model was constructed. I will now use Tracy's data to back up the ETCAP model and discuss how Tracy's change processes are represented in the ETCAP model.

## **6. ETCAP Representation of Tracy's Changes**

The ETCAP model provided the framework to examine Tracy's change at a more detailed level. The ETCAP model was useful for categorizing the conflicts and dissonance that Tracy experienced as she learned TEFA pedagogy and the stages that she went through as she processed and adapted the new pedagogy to make it congruent with her way of being. Tracy's elements in the ETCAP model in Table 4 on pages 209 and 210 will now be described. In the first element of the ETCAP model, Tracy's beliefs and perspectives about personal, academic and professional aspects of her practice were identified. Tracy's sense of self which included her personality, her professional orientation, her competence and her expectations for herself and her students served as powerful determinants in her implementation of TEFA pedagogy. In the second element, Tracy perceptions of TEFA were documented as having the potential to give her "a better sense of when to move on" (TPPI y0) in her efforts to cover the curriculum, that TEFA could decrease the amount of time she spent on homework, and increase her students participation. Tracy also believed that she would have a "comfort level" (TPPI y0) with using the PRS technology. Tracy also believed

that there were some inconsistencies with TEFA and her teaching style, and believed that if she was implementing TEFA as presented in the PD course that she was breaking the rules.

In the Process in Personal Context element of the ETCAP model, Tracy believed that TEFA could help her fulfill the goals that she had for her students and the goals she had for herself. She also believed that TEFA could help her address deficiencies that she identified in her practice. Tracy acknowledged that it was not going to be easy, but that she was willing to experiment with the new pedagogy and be adaptive to its integration.

During Reconciliation, Tracy tried to rationalize why she should change her way of teaching and justify whether the benefits of TEFA were worth the time needed to implement it. A little uneasiness that may have been felt during stage 4 now surfaced as tensions and dissonance as Tracy confronted her way of being and tried to reconcile it with what she had observed as the rewards of using TEFA. To reconcile the new pedagogy with her way of being, meant Tracy acknowledging that the practice that she had worked nearly 20 years to build up was flawed or deficient in some way. This process of a teacher confronting her way of teaching, admitting her deficiencies and reconciling the new pedagogy with her way of being is reflective of Feldman's (1999) practical conceptual change theory. In the first year of the study, Tracy questioned herself in several data sources about why she was not using TEFA and PRS more frequently even though she acknowledged that it was beneficial to her and to her students. This indicates that at this time Tracy was only having partial success with reconciling TEFA with her way of being according to the ETCAP model.

In the Trial and Evaluation phase, Tracy tried out different ways of using TEFA, refined it, evaluated, tried it again, further modified and continued with trial and evaluation of TEFA until she was satisfied that it was meeting her needs and the needs of her students. As Tracy went through the Trial and Evaluation phase, she was influenced by her learning style of making incremental steady steps in trying different ways to make her use of TEFA more effective. There were many aspects of TEFA that Tracy tried, assessed and modified during the Trial and Evaluation phase. Some of the things that Tracy experimented with were different ways of relinquishing control during discussion and with the level of students' volunteerism and anonymity that she was comfortable with during WCD and with using WCD for different purposes. She was "fighting sense to cut discussion short", questioning whether she should continue making all students respond and was very cognizant of how the students reacted to what she was doing and paid attention to their verbal feedback.

Finally, in the Application and Simulation phase, Tracy adopted TEFA pedagogy and it became an integral part of her practice. She also made innovations to TEFA as represented in the PD course in a variety of ways that were considered of a very high quality by the university faculty. Tracy made innovations to TEFA pedagogy by acting in the role of a scribe to facilitate whole class discussion and by designing a new type of question that was not modeled in the PD. At the end of the study, Tracy continued to use TEFA in innovative ways to increase students' motivation and experiment with homework. (See Table 3: Tracy's Elements of Change on pages 213 and 214).

**Table 3: Tracy's Elements of Change**

Categories	Elements of change	Tracy's Elements
a) Way of Being	1. Sense of Self	Teaching high school for over 20 years Teaching AP Chemistry and Anatomy Very confident teaching Chemistry, less confident teaching Anatomy Competent traditional teacher with frontal mode orientation "Control freak" Strong reflective skills Likes being a student and being assessed Likes variety-for entertainment and to "keep it fresh" Positive and enthusiastic Has high expectations for students to be proactive learners Confident with technology
	2. Perception of Pedagogy	Technology that she could have a "comfort level" with in class. Values formative assessment potential Could improve student participation, WCD and decrease amount of time spent on homework Some inconsistencies with her style of teaching; "Interpreting this pedagogy is supposed to work, is that the teacher is really not supposed to be in the front" TEFA has rules - when not implementing pedagogy as represented in PD "I broke the rules"
	3. Process in Personal Context	Could satisfy need to learn new pedagogy every year Could help her with problem with summarizing lessons Could give her insights of when to reteach or move on – Formative Assessment Could help students better understand concepts Could encourage students to challenge science Could help students develop roles as advocates that defend what they believe Time is limited and poses a problem Some misfit with style of teaching Willing to adapt, despite frustrations
b) Tensions & Dissonance	4. Reconciliation with Way of Being	Helps to improve her professionally Helps achieve her goals for students being proactive engaged learners Helps to better address the needs of students Helps her learn more about herself
	5. Translation	Learning style - learning new things slow and steady a little at a time influences use of TEFA Trying to fit PRS in the sequence of lessons/units Ensuring all students participate in WCD

**Table 3: Tracy's Elements of Change (continued)**

Categories	Elements of change	Tracy's Elements
b) Tensions & Dissonance (continued)	5. Translation (continued)	Developing new way of writing questions Using the "Oops, go back" question to challenge students' understanding and new type of question she developed Using PRS to establish logical proof Experimenting with ways to relinquish control in WCD Experimenting with PRS to assess homework Varying pace of lessons first in anatomy and not in AP Chemistry - test driven Inserting mini lessons to address students' needs revealed by TEFA Using less directed labs
	6. Trial and Evaluation	Tug-of-war between breadth vs depth – Does varying pace show that depth more beneficial than breadth? "Fighting sense to cut discussion short" – Would shorter discussions encourage students to defend their answers and challenge each other Wrestling with all students participating vs volunteerism and anonymity – Are students engaged if they do not participate? Wrestling with students' expectation to be told answers and her need to bring closure – Does telling answers foster proactive learners? Rationalizing why she's not using PRS more often Trying to relinquish control of central role in WCD – Is WCD more student-driven? Are the ways that pedagogy is being used working?
c) Simulation and Application	7. Simulation and Application	Change in beliefs and way of thinking about covering curriculum Eliciting thinking more important than covering curriculum Change in beliefs about time needed to do TEFA Using less lectures and more discussion to evaluate students' thinking Using WCD for new purposes Allowing students more time to think and come to their own conclusions Partial change in belief of need to be in control Changing dynamics of class to be more student driven by stepping back more Improvement of Skills Using a more introspective approach in writing questions Conducting and Managing WCD improved
	8. Innovation	Emergence as a scribe for whole group discussion Crafting type of question more complex than those modeled in PD Using TEFA and PRS in a variety of ways not modeled in PD

**a. Summary**

In this part of Section J, I have discussed the use of empirical evidence to construct frameworks and models that are used to gain a better understanding of phenomena that occur in a teacher's practice. I have also described three models of teachers' change which were: 1) Elements of Teacher Change in Adoption of Pedagogy Model (ETCAP), 2) Shulman (1986, 1987, 1990, 1992) Model of Pedagogical Reasoning, and 3) Feldman (1999) Model of Practical Conceptual Change. Additionally, I have compared and contrasted the latter two models, Shulman's and Feldman's, with ETCAP and outlined similarities and differences between the three models of teacher change. Finally, I showed elements of Tracy's change using the ETCAP model.

Various elements of change were exhibited in Tracy's practice as she adopted new TEFA pedagogy. As Tracy's practice evolved over the two year duration of this study, there were certain processes that occurred as she learned and adopted TEFA and PRS. After pointing out the similarities and differences of the three models, I made a rationale for why I developed the ETCAP model because Feldman's and Shulman's model did not effectively represent the fine details revealed in the data about Tracy's change process. The ETCAP model is an empirical model that was developed from the data used for this study. The ETCAP model emerged as a major outcome of this study. The ETCAP model is micro examination of Beatty, et al 2008 Co-evolution of Practice and Pedagogy Model. Data from the seven sources that informed this study guided the formation of themes and theories that were used to develop the ETCAP model.

## **K. Conclusion**

In Chapter 4, I have discussed some of the complexities of teaching and some of the difficulties that teachers experience while learning a new pedagogy. I have described the Co-Evolution of Practice and Pedagogy Model (Beatty, et al, 2008). Next, I described Tracy's jostling and struggling with the tensions that she experienced as she learned the TEFA pedagogy. Then, I discussed changes that the data revealed in Tracy's practice. This was followed by the factors that had a strong influence on the evolution in Tracy's practice. Next, I examined the impact that the SSSPD model had on the changes that occurred in Tracy's practice during the two year period. Finally, I have examined and compared three other models of teacher change.

### **a. Findings –Effects of Implementing TEFA**

Tracy gave credit to TEFA for helping her address areas in which she had been feeling ineffective in a variety of data sets. Some of these areas included using formative assessment which informed her planning so that she could effectively vary the pacing of her lessons, being more effective in challenging what students believed, eliciting students' thinking, helping students develop skills in defending their answers and bringing closure to her lessons. The data revealed changes in Tracy's beliefs, in her skills, in how she approached her planning and in her interactions with her students. Tracy embraced TEFA and PRS and used this new pedagogy to further refine her initial skills and apply them to many different areas of her practice. TEFA provided the springboard for Tracy to expand her repertoire of skills as TEFA illuminated what was missing in her students' knowledge, gave her specific insights about herself and her

practice and put her in a better position to prescriptively address the difficulties that her students experienced.

**b. Findings - Effects of SSSPD**

Analysis of the data suggest that there may have been a relationship between the SSSPD model and the changes observed in Tracy's practice. Additionally, the data revealed that Tracy believed that the SSSPD had a positive impact on her practice and that it was pivotal in the evolution of change that occurred in her practice during the two years of this study. The SSSPD model provided long term consistent coaching and technical support through weekly sessions during the first year and monthly sessions during the second year. According to what Tracy said in the seven data sources, it seems that the structure of the regular sessions in providing instruction that targeted different skills throughout the first year assisted Tracy in making steady progress in learning and integrating the TEFA pedagogy. However, these findings should be taken with caution because the data sources used for this study could not conclusively reveal insights about the effects of the SSSPD, or accurately reveal any causal relationships between the SSSPD and the changes observed. This was a limitation of this study that supports the need to include questions in future data collection instruments that specifically explore effects of the SSSPD.

## **CHAPTER V**

### **DISCUSSION AND IMPLICATIONS**

#### **A. Introduction**

This study explored factors that analysis of data revealed about the impact of Sustained School Situated Professional Development (SSSPD) by studying teacher learning of Technology Enhanced Formative Assessment (TEFA) in a teacher who emerged as an exemplar, which was the main research question guiding this study. Longitudinal analysis of the data over the two year duration of this study revealed two major findings which were: 1) implementing TEFA led to changes in Tracy's practice, and 2) Tracy believed that the professional development model was instrumental in her learning how to implement TEFA. Findings also revealed changes in the participant's beliefs and educational philosophy. An outcome of the study was the development of the Elements of Teacher Change in Adoption of Pedagogy (ETCAP) model that mapped eight elements of teacher change that were experienced by Tracy as she learned and implemented TEFA.

#### **B. Changes in Tracy's Practice**

How has the participant's practice changed over a period of two years as she integrated TEFA pedagogy into her practice?

The findings revealed that as Tracy's practice evolved, changes occurred in her practice that included changes in her beliefs, knowledge, skills and in her use of TEFA pedagogy which is supported in the literature (Levin & Wadmany, 2007; King, 2007; Wood et al, 2005; Hokanson & Hooper, 2004; Haney, et al, 2003; Earle, 2002; Ertmer,

1999). Teachers' beliefs are an important consideration by persons planning professional development (Loucks-Horsley, 1998) because teachers' beliefs, attitudes and behaviors affect their implementation of new pedagogy (Lumpe & Chambers, 2001). The results revealed that Tracy's identity and image as a teacher were shaped by her philosophy and beliefs which is supportive of existing theories about teacher image and identity. These theories support the development of a teacher's identity as a dynamic and continuous process as multiple experiences continually mold, inform and reform the teacher (Levin & Wadmany, 2007) and have a strong impact on how teachers construct a view of themselves as teachers (Page, et al, 2004). Teachers will only adopt new practices that are consistent with their beliefs and perspectives. A teacher's perspectives about integrating technology into the classroom could either facilitate the integration of the technology or be a barrier to using technology (Levin & Wadmany, 2007; Ertmer, 1999).

Tracy was an adept teacher who made practical applications of pedagogical content in her planning, in her teaching and in her adoption of TEFA (Danielson, 1996; Shultz, 2005). Tracy showed seemingly rapid facility in learning and adopting TEFA, however careful scrutiny of the data revealed that there were many processes and transitions that Tracy experienced that were conflated giving the appearance of TEFA being easy for her to implement. These findings support the view that a proficient teacher makes the very complex processes of teaching seem very easy because generally the experienced teacher has internalized the skills (Shultz, 2005). Teacher learning of TEFA is a complex undertaking in which the teacher undergoes many processes before the new pedagogy could be internalized and become a natural part of their practice

(Feldman & Capobianco, 2008). Before internalization of new pedagogy could occur, the teacher actually has to change his or her way of being which involves redefining who he or she is as a teacher which then leads to change in actions and beliefs (Feldman, 2002; Feldman, Paugh & Mills, 2004).

As teachers implement new approaches, change could occur in many aspects of their practice. Changes in Tracy's practice occurred in three areas: question construction, pedagogical methods, and in curriculum integration, all of which are supported by findings of Feldman & Capobianco (2007). Tracy changed her beliefs about the time needed to cover all of the curriculum to believing that she should put less emphasis on covering the curriculum and more priority in eliciting students' thinking. In support of King's (2007) findings, the results show that although Tracy felt constrained by time which was a major tension for her, she was committed to enact her new belief that eliciting student's thinking was more important than making sure that she covered the breadth of the curriculum. Tracy was prepared to enact her new belief despite the perceived time constraints that may have impeded successful implementation of TEFA. Tracy's belief that students should be told the answers to problems if they were challenged also changed. Tracy's belief that she needed to be in control was resistant to change, but some progress was made in this area. This study demonstrated that teachers' beliefs can change, although some beliefs are so entrenched that they are difficult or resistant to change, which is supported in existing literature (Levin & Wadmany, 2007). It is easier to change beliefs if teachers are receptive to change and are willing to evaluate their beliefs in light of new experiences (Levin & Wadmany, 2007). In addition to supporting the literature about beliefs being resistant to

change, this study was able to show an example of the progression of changes in Tracy's beliefs as they were mapped on a timeline that is based on statements that Tracy made which acknowledged the changes that she recognized in her beliefs and in her practice.

Tracy changed from teaching as transmission of knowledge to teaching that facilitated restructuring and generation of knowledge, which supports Levin & Wadmany (2007) findings. This change was supported by Tracy's philosophy that she wanted her students to be proactive, engaged learners who embraced their roles as advocates. The results support the theory that changing Tracy's paradigm and mode of operation is a very complex process (Levin & Wadmany, 2007). The results are supportive of findings in the literature that teaching is a multifaceted, very complex intellectual, creative decision-making process (Shultz, 2005) in which teachers confront pedagogical issues and make choices about methodology to use to assist students to acquire knowledge, construct beliefs and apply new information (Shultz, 2005, Danielson, 1996). For integration of new pedagogy to be successful, the pedagogy must be supportive of and must positively influence existing beliefs or have a very strong impact on changing the teacher's existing beliefs (Lumpe & Chambers, 2001; Haney, et al., 2003; Levin & Wadmany, 2007).

A teacher's attitudes, beliefs and perspectives play an integral role in the teacher's definition of tasks and in his or her selection of cognitive tools with which to interpret, plan and make decisions (Shulman, 1986, 1987, 1990, 1992; Haney, et al., 2003). Teachers must have a good grasp of the subject matter that they teach and be able to make practical application of their content knowledge in the classroom (Feldman, 1999). This is not a simplistic procedure and it takes an adept teacher to

effectively make practical applications of pedagogical content as he or she goes through the many processes of planning and teaching (Shultz, 2005, Danielson, 1996).

The results suggest that Tracy's image of herself – her sense of being continued to evolve throughout the study which supports Feldman's (2002) belief that teachers are constantly being influenced and shaped by their experiences. The findings are indicative of the strong relationship between the beliefs and perceptions of teachers on the instructional decisions that they make (Lumpe & Chambers, 2001; King, 2007). The results also support Levin & Wadamy's (2007) findings that teacher's beliefs guide their instructional mode and their curricular decision making.

Tracy had to evaluate her beliefs and assess if they were facilitating what she needed to accomplish in the classroom (King, 2007). Tracy had to become discontent with her old practice and embrace the new TEFA pedagogy as sensible, beneficial and enlightening which is supportive of Feldman's (1999) model of Practical Conceptual Change. The results provided evidence that Tracy confronted her way of teaching, identified deficiencies and reconciled the new pedagogy with her way of being as she experienced and resolved tensions (Feldman, 1999).

As Tracy's beliefs evolved, it became easier for her to implement TEFA pedagogy and to use it in innovative ways (Beatty, et al, 2008; King, 2007; Levin & Wadamy, 2007). This study explored the evolution of Tracy's beliefs as she learned and integrated TEFA, which adds a new perspective to the literature since this researcher knows of no other studies that track changes in a teacher's beliefs while learning TEFA pedagogy while participating in SSSPD. The findings are reflective of the literature about how a teachers' identity is formed and how the identity influences what teachers

do in the classroom. The results are supportive of Page, et al (2004) findings that multiple experiences have a strong impact on how teachers construct an explicit view of themselves as teachers. The results also underscore Feldman's (2002) theory that a teacher's identity, their sense of self and their way of being as a teacher are formed by experiences and encounters that the teacher had and directs what s/he does in the classroom. This study supports Levin & Wadmany's (2007) theory that the development of a teacher's identity is a dynamic and continuous process as multiple experiences that continually mold, inform and reform the teacher (Levin & Wadmany, 2007).

### **C. Facilitators and Precursors of Change**

Are there predictors that may facilitate change in the practice of this participant? If so, what are the predictors that assist the participant to integrate TEFA into her practice?

Analysis of the data revealed several factors that facilitated change in Tracy and in her practice as she adopted TEFA pedagogy. These factors emerged as strong traits in Tracy's personality and they were instrumental in shaping what Tracy did in the classroom. These factors were Tracy's confidence and competence as a chemistry teacher; her perception of the nature of science; her self reflection; her willingness to be assessed by others; her need for variety in her teaching; her learning style; her expectations for TEFA professional development; her expectations for her students and the early success she experienced with TEFA.

There are volumes of literature about constraints and barriers that may impede teachers' integration of technology into their practice (Ertmer, 1999; Earle, 2002; Hokanson & Hooper, 2004; Wood et al, 2005). There is also literature about factors

that hinder or support teachers learning of pedagogy. What this study adds to the literature is a list of factors that facilitated Tracy's adoption of TEFA pedagogy that speaks uniquely to her beliefs and practice. These factors could serve as indicators or prerequisites for exemplary integration of new pedagogy for other teachers who may be similar to Tracy in what they believe and what they do as teachers. Caution should be taken because this list of factors is limited only to Tracy and facilitators of pedagogy integration of other teachers could be different. This limited list supports the need for more research in identifying factors that facilitate pedagogy integration.

#### **D. Effect of SSSPD Model on Change**

How does the SSSPD model affect the participant's practice while implementing the TEFA pedagogy?

This study demonstrates that the SSSPD model had a positive impact on the changes that occurred in Tracy and in her practice. The findings also show that Tracy believed that the SSSPD model was of benefit to her as she implemented TEFA pedagogy and made changes in her practice. From the data, it may be presumed that the site-based, frequent meetings of the SSSPD model that were sustained for the two years of the study influenced the changes in Tracy's beliefs and in her classroom practices. However, there is no conclusive evidence in the data to show this.

Tracy attributed her motivation to do TEFA and to try out new things using TEFA to the frequency and longevity of the SSSPD. Tracy believed that the PD kept her focused on TEFA. The longevity of professional development facilitates the reinforcing, reshaping and redefining of teachers' practice (Kohler, et al, 1997; Supovich & Turner, 2000; Guadelli, 2002; Johnson, et al, 2007). The findings support

the literature that states that sustainable professional development allows teachers to identify and examine the complexities of teaching and engenders change in the teachers' thinking and practice while they learn a new pedagogy (Leonard, et al., 2004; Beatty, et al, 2008; Eylon, Berger & Bagno, 2007; Taitelbaum, et al, 2007; Gatsby Technical Education Projects, 2006; Johnson, et al, 2007). The results also support Evans' (2002) and Fraser's (2005) findings that PD that is sustained with continuous engagement facilitates internalization of new knowledge and skills. The results from this study demonstrate these intrinsic characteristics of continuous engagement, longevity and sustainability of the SSSPD model and its impact in redefining and recreation of who Tracy was as a teacher. The impact of SSSPD was reflected in the many references that Tracy made about the role of TEFA professional development and the faculty in assisting her to evaluate her practice and change her beliefs and her way of teaching. This study adds to existing literature findings with regard to the interplay of teaching strategies and the fluidity and adaptability of the SSSPD model in teacher learning and integration of TEFA pedagogy.

From the results, it may be inferred that the SSSPD model gave Tracy opportunities to reflect on her teaching and to use collaborative feedback from the faculty facilitating the PD course and from the other participants in the TEFA project. From statements made by Tracy in the data, it seems that the interaction and collaborative feedback was a significant factor in changing Tracy's practice and in sustaining the changes over time. The findings from this research suggest that collaborative discourse in sustainable professional development helps to reveal teachers' tacit and hidden knowledge, clarifies teachers' understanding, helps teachers construct

new knowledge, and reinforces their pedagogical identity (Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006). The findings show that Tracy had a greater awareness of herself and of some character traits that she was not conscious of before being a beneficiary of the frequent and sustained PD. Teachers' in depth reflection and analysis of their practice and their development of a greater awareness of who they are as teachers are prerequisites for them changing their practice (Feldman, 2003).

These findings are supportive of findings from other studies that reveal that sustainable professional development assists teachers to deepen their content and pedagogical knowledge while providing opportunities for them to reflect on their teaching in a formative collaborative environment (Goldenberg & Gallimore, 1991; Gaudelli, 2002; Gusky, 1994, 2000, 2003; Feldman & Minstrell, 2000; Feldman & Capobianco, 2000, 2007; Loucks-Horsley et al., 1998; Supovich & Turner, 2000; Johnson et al, 2007). Additionally, sustainable professional development as afforded by the SSSPD provided consistent support and assistance that facilitated Tracy's integration of the new pedagogy into her practice (Killion, 1999; Supovich & Turner, 2000; Guskey, 2000; Evans, 2002; Guadelli, 2002; Fischer et al., 2004; Fraser, 2005; Eylon, Berger & Bagno, 2007; Taitelbaum, et al., 2007; Gatsby Technical Education Projects, 2006; Johnson, et al., 2007; Leonard, et al., 2004; Beatty, et al., 2008).

#### **E. Model of Teacher Change**

How could the findings be used to develop a model of teacher change?

The results show that the changes in Tracy's practice were shaped by the continuous process of evolving states and changes in the Co-Evolution of Teacher and

Pedagogy Model (Beatty, et al., 2008). According to Beatty, et al (2008), the change processes that Tracy experienced were characterized by struggles, conflicts and tensions which had to be resolved before change could occur. This study refined the Co-evolution Model by exploring different facets to the change processes experienced by Tracy. These change processes were examined in greater detail and more minutely than was done by the Co-Evolution of Teacher and Pedagogy Model (Beatty, et al (2008). This micro examination and expansion of the Beatty's model led to the development of the Elements of Teacher Change in Adoption of Pedagogy (ETCAP) model which provides a more comprehensive view of teacher change.

The results of the study revealed that Tracy experienced the elements of the ETCAP model in different ways as she looped back and forth through the phases of the model while learning TEFA. The foundational plank of the ETCAP model is Tracy's way of being a teacher – her sense of self (Feldman, 2002). This is followed by the Perception of Pedagogy element as Tracy formulated her perception of TEFA. Findings showed that Tracy processed TEFA into her personal contexts by evaluating whether TEFA could help her achieve the goals that she had for her students and for herself. Tracy reconciled TEFA with her expectations and anticipated rewards she would receive from the time and effort she intended to invest in the new pedagogy. This reconciliation facilitated Tracy trying TEFA and evaluating it resulting in her refining and redefining what she was doing (Kohler, et al., 1997) before settling on a form of the TEFA pedagogy that she integrated and that became a natural part of her practice. This is reflective of the simulation and application element of the ETCAP model. Then the

final phase of ETCAP is the recreation of TEFA in innovative ways in different contexts which is the innovation phase of the ETCAP model.

#### **F. Conclusion**

Implementing TEFA led to changes in Tracy's practice. Tracy's educational philosophy and beliefs facilitated her learning and adoption of TEFA. Tracy's way of being; who she was as a teacher and what she did in every aspect of her teaching also had an impact on the changes that occurred in Tracy's practice. Additionally, Tracy's pedagogical content knowledge and the practical applications she made of the new TEFA pedagogy also influenced Tracy's implementation of TEFA.

Tracy's practice evolved as she grappled with tensions and experimented with different ways of implementing TEFA in an effort to resolve the tensions that she was experiencing. As tensions were resolved and benefits realized, changes occurred in Tracy's beliefs and in her practice. As findings from the data illuminated the change processes that Tracy experienced, this underscored the need to examine these processes in more detail. Out of the need for more in depth examination of the changes that occurred in Tracy's practice, the Elements of Teacher Change in Adoption of Pedagogy (ETCAP) model was developed. The development of the ETCAP model was a major outcome of this study. ETCAP supports the Co-Evolution of Teacher and Pedagogy Model (Beatty, et al., 2008).

The Sustained School Situated Professional Development model was instrumental in Tracy learning how to implement TEFA. The findings showed that the changes in Tracy's beliefs and in her practice were facilitated by frequent, prescriptive meetings that were held weekly during the first year and once a month during the second

year. The collaborative interaction and the timely support and follow-up of SSSPD not only facilitated change in Tracy's practice, but were instrumental in sustaining those changes over time.

### **G. Implications**

Gaining a better understanding of the SSSPD model and its potential as an effective model for PD could give valuable insights about its effectiveness in promoting teacher change and sustaining that change over time. The findings from this study suggests that the SSSPD model used for the TEFA project was successful in promoting sustainable changes in what Tracy did in her classroom.

Persons planning professional development need to be cognizant of the relevancy and benefits of sustained professional development that feature frequent meetings with collaborative support and technical assistance that is continuous throughout the year. It is important for professional developers to know about the influence of a teacher's beliefs, philosophy and identity on the teacher's learning and integration of new pedagogy. It is also important for professional developers to be aware of the tensions and dissonances that teachers experience which have an impact on the teachers learning of new pedagogy and the resultant changes in the teachers' practice.

It is hoped that findings from this study could inform university faculty that implement the SSSPD model and assist them to refine the model. This study could also foster dialogue in the wider academic community about the processes of teacher change that could lead to the creation and implementation of more sustained professional

development approaches that could improve teachers' practice and thereby improve students' learning in science.

I make no claim that the ETCAP model could be applied to wider contexts in which other teachers are learning new pedagogy. The ETCAP model is representative of one participant's progress while she learned and integrated new pedagogy and may not be representative of a larger sample. Thus, the model should be viewed as a work in progress which is just in the foundational stage that has to be validated with further research done with larger samples. Therefore, the concepts of the ETCAP model may only be transferable to some degree in teacher learning and teacher change in other contexts. Although this is a limitation of ETCAP model of teacher change, the model could assist educators, professional developers and curriculum developers to have a better understanding of the processes of teacher change.

There are several outcomes of this research that contribute to the literature. Since research on SSSPD models that consist of a PD course and action research sessions is limited, this study informs the literature in this regard. This study provided insights about the impact that the SSSPD model had on the practice of a high school science teacher. It elucidated the pedagogical methodology and the implementation design of the SSSPD model and their role in influencing change in the participant. This study also contributes to the literature on PD models that offer frequent serial meetings facilitated by university faculty on the campus where the teachers practice. The findings from the study were instrumental in identifying predictors and facilitators of teacher change that could be used to assist teachers to successfully integrate TEFA pedagogy in the future. Additionally, the findings of this study generated new knowledge about how

a teacher learns new pedagogies which could be used to help teachers effectively integrate new pedagogy into their teaching. One of the a main contributions to the literature is the ETCAP model, which illuminates the multi-faceted processes that a teacher goes through as her beliefs and perspectives, pedagogical content knowledge and practical theories evolve as she learns and integrates new pedagogy.

## APPENDIX A

### LINKING DATA TO PROPOSITIONS

Seven data sources will be linked to propositions. The linkages between propositions and data sources are indicated by “X” in the table below. The seven data sources will be:

1. TEFA Philosophy and Perspectives Interview (TPPI)
2. Teacher Lesson Planning Interview (TLPI)
3. TEFA Teacher Video-Based Interview (TVBI)
4. TEFA Classroom Observation Protocol (TCOP)
5. Action Research Group (AR)
6. Teacher Monthly Reflection Survey (TMR)
7. Participant’s Journal

Propositions	Data Sources						
	TPPI	TLPI	TVBI	AR	TCOP	TMR	Journal
a. Participant’s learning process and development of skills	X		X	X	X	X	X
b. Participant’s ability to reflect on and analyze her practice	X	X	X	X		X	X
c. Participant’s adaptability and willingness to change	X	X	X	X	X	X	X
d. Imbedded behaviors and beliefs that are resistant to change	X	X	X	X	X	X	X
e. Supportive frameworks of the SSSPD	X	X	X	X		X	X

## APPENDIX B

### ACRONYMS, GOALS AND TIMELINE FOR DATA SOURCES

Data Sources	Acronym	Goal	Administration Timeline		
			Baseline	Year 1	Year 2
1. TEFA Philosophy and Perspectives Interview	<b>TPPI</b>	To explore the participant's philosophies and perspectives	July 2006	May 2007	
2. Teacher Lesson Planning Interview	<b>TLPI</b>	To explore the participant's lesson planning processes	May 2006	November 2006 April 2007	
3. TEFA Teacher Video-Based Interview	<b>TVBI</b>	To discuss participant's thoughts about changes in her practice		January 2007	
4. Action Research Group	<b>AR</b>	To encourage peer collaboration, self reflection and investigation of practice		Once a month	Once a month
5. TEFA Classroom Observation Protocol	<b>TCOP</b>	To video-tape participant's use of PRD and TEFA in her classroom	April 2006	October 2006 December 2006 March 2007 April 2007	October 2007 November 2007 February 2008
6. Teacher Monthly Reflection Survey	<b>TMR</b>	For participant to report on her experiences with TEFA and PRS		Once a month	Once a month
7. Participant's Journal (Not represented by acronym)	<b>Journal</b>	For participant to record experiences with TEFA and PRS		Entries determined by participant	Entries determined by participant

## APPENDIX C

### TEFA PHILOSOPHY AND PERSPECTIVES INTERVIEW (TPPI)

#### Introductory Comments

To the interviewer: try to stay focused on the subject's beliefs, rather than on the details of their practice. Some questions ask for examples, but in general we want to prevent subjects from going on and on about all the things they do in the classroom. When a subject gives a detailed, specific example in response to a general question, try to get them to articulate what it is about that example that answers the question. Many subjects will have to think of specific examples in order to figure out an answer, but we don't want to be guessing how a story about what one student did answers a question about the subject's beliefs. We want the subject to state the belief.

This is the TEFA Philosophy and Perspectives Interview with subject [code#] on [date].  
Thank you for participating in this study. [Pause]

This interview has 33 questions, plus a few follow-ups to those questions.

#### Questions

1. How do you see your responsibility and purpose as a teacher?
2. How would you like your students to be different after the course is over?  
(Can you be specific? Are there any other ways in which you'd like them to be different?) [Probe hard, push for a comprehensive response.]  
→ Is it possible and realistic to achieve these results with your students?  
(Why or why not, and with which students?)
3. What other goals do you have for your students that motivate or shape your teaching? (Perhaps things that are less formal, or more personal, or outside the boundaries of the subject?)
4. What do you think makes something scientific (mathematical) knowledge rather than other types of knowledge?
5. How would you describe meaningful learning?
6. What do you consider evidence that a student has learned a particular subject really well?
7. How do you see your roles and responsibilities in the classroom?
8. How do you see the students' roles and responsibilities in the classroom?
9. How do you try to motivate students to learn, and why?  
→ Can you change or impact the factors that motivate a particular student?  
(How? For how many students? Which ones?)

10. What are the general characteristics of good, helpful feedback for students? (Can you give me an example of this?)
11. What are the characteristics of good, helpful whole-class discussion? (Can you give me an example of this?)
12. What are your objectives for this course? What do you hope to accomplish by teaching it? [Pick a typical course, preferably one that TEFA is being used or will be used in.]
  - If you accomplished these, what would the observable results be? What would success "look like"? (Can you give me an example from your teaching?)
13. Are there any general, recurring tensions or trade-offs that you face when making instructional choices? (What?)
  - How do you resolve these?
  - Do you perceive a tension between covering sufficient material and covering certain material really thoroughly? [Only ask this if it hasn't come up. You can also use it as an example of a recurring tension or trade-off if the teacher doesn't know what we mean by this.]
  - If so, how do you handle it?
14. When you begin or introduce a new topic, what are the most important things that you try to do?
15. If students don't understand a concept, what kinds of things do you do to help students "make sense" of it?
16. In what ways is cooperative or peer learning among students beneficial?
17. What role do grades serve in your instruction?
  - Do you see a tension between evaluating all students according to a uniform standard, and taking students' individual abilities, starting points, and effort into account?
  - If so, how do you handle it?
18. In what ways do you provide feedback to students, and why?
19. For what purposes do you use whole-class discussion?
  - How do you run a whole-class discussion?
  - During classroom discussion, what kinds of considerations do you pay the most attention to?
20. When a student says something incorrect, how do you handle it? (Can you give me an example?)
  - What considerations are on your mind when you respond to a question that a student asks you?

21. All teachers have experienced a class not going at all how it was planned. When this happens to you, how do you feel? (Why?)
22. Imagine a class in which really good learning is happening, and everything is going as perfectly as you could hope. Please describe what this looks like.
23. What are the characteristics of a good or successful learner?  
→ Is it possible for students to become better learners? (How? For how many students? Which ones?)  
→ What, if anything, can you do to help a student become better at learning?  
→ What is the most beneficial thing a student can do to improve his or her learning?
24. [Baseline] I know we haven't really talked about these yet, but if you have any thoughts or expectations about "classroom response systems" and "technology enhanced formative assessment", what do you expect the benefits of using these to be?  
→ What do you think the drawbacks might be?  
[Non-baseline] What do you see as the primary benefits of using a "classroom response system" and "technology enhanced formative assessment"?  
→ What do you see as the drawbacks?
25. How satisfied are you with what you accomplish in the classroom? (Why?)  
→ How dissatisfied are you with what you accomplish in the classroom? (Why?)  
→ Are there any other ways in which you are dissatisfied with teaching? (Please explain.)
26. How confident do you feel about your scientific or mathematical knowledge of the topics covered by this course?  
→ [If less than confident] How do you think that this affects your teaching?
27. [Baseline] In terms of your personal and professional objectives, what do you hope to get out of this professional development program? (Why?)  
[Non-baseline] In what ways, if any, is this professional development program fulfilling your personal and professional objectives? (In what other ways would you like it to?)  
→ In general, how do professional development activities fit into your personal goals?  
→ If you had an opportunity to choose or create site-based professional development activities, what would they be?

## APPENDIX D

### TEACHER LESSON PLANNING INTERVIEW (TLPI)

#### **TLPI: Interview Administrative Instructions**

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##### **Goal & strategy of the TLP Interview**

The main point of the interview is to determine what considerations a teacher brings to lesson planning. The goal of the interview is to surface the teacher's cognitive models, heuristics, and considerations for lesson planning. The interview is anchored in a specific lesson plan or unit plan that the teacher has implemented at least once before. The goal for the interview data set is to capture change in the key areas in which we expect the TEFA intervention to produce change over time in teachers' lesson planning practices and conceptions. The protocol avoids asking direct questions on subtopics of interest because it would cue the teacher to the "right" or socially desirable answer from the outset, thus creating a ceiling effect, which would limit our ability to see and measure change over time. Instead, we will ask open questions, soliciting the teacher's internalized model of lesson planning, and using a TEFA listening lens to code the interview. Interview transcripts will be coded for in terms of aspects of lesson planning where change is expected as a result of participation in TEFA.

##### **Overview of the TLPI**

This protocol is designed to be administered to the teachers who are enrolled in the TEFA professional development course. Ideally you will have **60-75 minutes** to cover the interview. It is up to you to manage your time during the interview to cover all necessary parts of the protocol. This may mean helping the teacher to focus on the question asked in the event the teacher wanders off topic. In other words, you will have to be able to distinguish between "off topic talk" and a story or relevant point that we may not have anticipated. Please err on the side of allowing the teacher to talk off topic.

In addition to managing your time during the interview, you also need to *listen actively* to determine if a follow up question is warranted. For example, in response to the question about why the teacher has made changes to the lesson plan since s/he used it the last time, if the teacher says s/he has made changes based on "the reaction I get from the students. I have assessment techniques that I can see what's effective and what's not effective." In this case, you should ask the teacher to explain what techniques she used. For example, ask, "Can you say more about how you did that this time?" or "What assessment techniques did you use in this case?" Try to get the teacher to talk about what s/he did specifically for the lesson you and s/he are discussing, rather than talking about generalities or a range of strategies s/he likes to use. Try to keep things specific and anchored in what actually happened with the lesson under discussion.

The interview should focus on a unit or lesson plan that the teacher has implemented at least once before. The interview is designed to accommodate those teachers who come to the interview with only a few notes written down. Whatever the teacher brings, do not be judgmental if you find it “under- documented.” Also, whatever the teacher brings, ask the teacher how typical this is of her or his usual lesson or unit plan documentation. The interview is not designed to accommodate those teachers who come to the interview without a lesson plan or artifacts of any sort. If the teacher does not bring (or send ahead of time) any documentation of any lesson plan or activities, you will need to reschedule the interview for a time when s/he can have these available.

We want the interview to feel natural and personal, not as if you are reading questions from a script. At the same time, it is important to ask the questions as written and follow the protocol as closely as possible so that we have consistency across interviewers and interviews.

If the teacher does not understand a question or appears perplexed, try to reframe the question and be sure to mark the question for discussion with other interviewers.

### **TLPI: Interview Administrative Instructions**

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#### **General preparation tips**

- Review these instructions, the interview protocol, the TEFA Model, and any materials the teacher may have sent to you before the interview.
- Test your audio recording equipment to make sure it works. Make sure you have spare batteries for the mic and the recorder.
- Know the relationship your teacher has with the TEFA project so that you can acknowledge their role and contribution to the project to date.
- Know what they teach (subject, grade level).
- Confirm the interview the day before.

#### **TLPI logistics**

- Materials: interview guide, audio tape recorder, audio tapes (if needed), spare batteries, paper and pencil for notes. Bring the lesson plan and related materials to the interview if the teacher sent them ahead of time.
- The teachers will be interviewed individually by one researcher.
- Length of interview is expected to be 60 to 75 minutes
- The interview will be audio taped and will be conducted in person.
- DURING THE INTERVIEW: when teachers refer to artifacts, saying, “this” or “that” or “right here” or “what I wrote here,” because this is audio taped, please

stop to specify for the audio record what the teacher is pointing at. The goal is to make it possible for someone listening to the audio recording to identify the artifact to which the teacher was referring.

- In scheduling the interview, the interviewer will ask the teacher to focus on a lesson plan that she or he has implemented at least once before and that is fairly typical for that teacher. The interviewer will ask for a copy of the unit/lesson plan, if available, and any available artifacts (e.g., specific worksheets or handouts used in the activities, lecture notes, etc.) in advance of the interview or will ask the teacher to bring them to the interview. (The interviewer should be prepared to copy and return the documents to the teacher if the teacher did not bring a copy for the researcher.) Confirm whether or if the lesson plan is one the teacher has used. The interviewer will be prepared to work from artifacts such as the teacher's written outline or notes of the lesson if a written "plan" is not available. Additionally, the interviewer will be prepared to work with and from artifacts or supplemental materials such as handouts to focus the interview.
- Make sure the teacher does not bring a lesson plan that s/he used (or is considering using) for the TEFA observation.
- The lesson plan materials will serve as the basis for discussion or at least the touching off point for the interview.

**Part A: Introduction**

The following is a suggested introduction. When you begin the interview, make these points, but use your own words for a more personal introduction. The introduction below is written as if this is our first visit with this teacher; please acknowledge your ongoing relationship with this teacher if appropriate.

Confirm that the interviewee has brought some lesson plan artifacts to the interview.

Thank you for agreeing to meet with me today. As a member of the professional development course on Technology Enhanced Formative Assessment (TEFA), you are aware that we are conducting a study of TEFA. The purpose of the research study is to understand teacher learning of TEFA-based pedagogy and to improve our methods of teacher professional development in TEFA for the future. Today we are going to discuss lesson planning; in general we want to learn what you take into consideration when you are designing a lesson plan. I will be audio taping the interview, if that's alright with you, so that I do not need to take extensive notes during our conversation.

Do you have any questions before we get started?

**Part B: Overview questions**

1. Materials & course check

- a. Let's take a quick look at what you brought with you today. Did you bring any other related materials with you such as handouts? [Gather materials and confirm if this is a copy for you to keep or if you need to copy and return to the teacher.]
- b. I know that you teach [subject and level]. What specific class did you develop this lesson plan for (e.g. geometry, chemistry, chemistry honors)?

2. Context

- a. Help me put this lesson plan [or unit plan] in the context of the course. I know many teachers plan lessons within units. [If LP:] What is the unit in which this lesson fits? What came before this lesson [or unit] (what topics in the unit preceded this topic)? What follows it (what topics in the unit follow this lesson) a day or two later?

3. History

- a. Did you design this lesson yourself or did you locate it from a source?
  1. [If located] What was the source?
  2. [If located] Did you make any alterations to it? [If yes] Tell me about those.

- b. Have you interacted with or sought feedback from anyone else (e.g., other teachers at your school, a department head, or any other network of teachers) in developing or revising this lesson/unit plan? (8B)
- c. When did you last use this lesson plan? (e.g. this year? semester?) [Try to get specific month.]

- 1. Did you make any changes after using it the last time?

Why? (8A1) [If teacher suggests something interesting such as saying she changed the lesson based on “reaction from students,” ask what that reaction was (trying to get a sense of the evidence the teacher used to judge the reaction] and how she changed or plans to change the lesson.]

- 2. [If they haven’t changed it] Would you change anything about the lesson before using it again? Why?

#### 4. Goals

- a. Please tell me what your specific instructional goals are for this lesson. What do you hope it will accomplish? (2A, 2B)

- 1. Why did you select that goal(s)? (2A)

#### 5. Lesson Plan Design

- a. Please talk me through the lesson plan. I’d like to understand your view of the design, and how the parts work together. Tell me about the different parts of the lesson, and why you included each part. 2C

- 1. What are the purposes or goals of this [part/question/activity/etc.]? (2C,3A)
  - 2. Why did you choose this mode or approach to accomplish that purpose? (2C,3B)
  - 3. [For discussion questions, CRS questions, activities, etc.] Why did you choose this particular question/activity/etc?
  - 4. Ask similar "why" questions about relevant materials or other artifacts with this part of the lesson.] (2C,3)

#### 6. Alternatives

- a. Is there anything you considered including, omitting, or doing differently, but decided not to? Why? (2)

#### 7. Assessment [If not already discussed in review of the parts of the lesson plan]

- a. Was there any kind of formal or informal evaluation or assessment of students linked to this lesson? [If yes] Tell me about that.

#### 8. Plan Implementation

- a. When you used this lesson, did you end up doing anything differently from how you had planned it?
  1. [If yes] Tell me about that. [Why?]
  2. [If no] Is there anything that *could* occur in the classroom while delivering this lesson that could cause you to change course during the class? (Can you think of anything or is that unlikely?)

#### 9. Retrospective

- a. Overall, was the lesson successful? How or how not? (8A1)
  1. Why do you say that? (What information are you using to decide that?) (8A1)
  2. Tell me about any parts you were particularly happy and *not* happy about. Why? (8A1+)
    - i. Why do you say that? (8A1+) Tell me about those. (8A1+)

#### 10. General

- b. Is this plan typical for you, in style and degree of detail?
  1. [If not] How is it not typical?

### **Part C: Wrap-up & Closure**

1. Is there anything you want to add that would help us understand what you consider or keep in mind when designing a lesson?

Thank you, again, for your help with this study. We greatly appreciate your investment of time, energy, and effort.

2. Do you have any questions for me as we conclude?

## **APPENDIX E**

### **TEFA TEACHER VIDEO-BASED INTERVIEW (TVBI)**

- 1.0 Has your teaching changed between last year and this year?
  - 1.1 If so, in what ways?
  - 1.2 Can you give me an example?
- 2.0 Can you attribute any of the change to TEFA? In what ways?
  - 2.1 To the hardware/software?
  - 2.2 Use of the questions?
  - 2.3 Ways of using the questions for classroom interactions?
- 3.0 Do you remember the class that we videotaped last academic year?
  - 3.1 What class was it? What level?
  - 3.2 How would you describe the students?
  - 3.3 What were your expectations for the students?

#### **SHOW BASELINE VIDEO**

- 4.0 Was this a typical class?
  - 4.1 Do you have any other comments?
- 5.0 Can you talk about what you were doing and why in this clip?

#### **SHOW TEFA VIDEO**

- 6.0 Was this a typical class using TEFA?
  - 6.1 Do you have any other comments?
- 7.0 Can you talk about what you were doing and why in this clip?
- 8.0 After seeing the two clips, are there any changes in your teaching that you are now aware of that you didn't tell me about before?
  - 8.1 What precipitated these changes?
  - 8.2 How did you learn to do this (agile teaching)?
- 9.0 Is there anything that you'd like to add?

## **APPENDIX F**

### **TEFA CLASSROOM OBSERVATION PROTOCOL (TCOP)**

#### **Pre and Post Observation Interview**

##### **Pre-Observation Questions (All visits)**

1. What are your instructional goals for today's lesson?
2. In terms of your unit plan, what came before today's lesson? What will follow this lesson in your unit plan?
3. What particular aspects of the content do you anticipate students will find challenging or confusing?
4. Do you have a particular game plan for addressing these area(s)? (If so, probe.)  
(Note: we should not ask this question in a way that assumes teachers have such a plan, hence the yes/no question with probe. In responding, teachers will likely automatically elaborate on their yes/no answer even without the probe).
5. Is there anything I should know about your students or your planned activities before you get started?

##### **Post-Observation Questions (All visits)**

1. How do you feel the lesson I observed today went? (probe if necessary)
  - a. What went well? Why?
  - b. Is there something you wish you could do over? Why?
2. Did students have the confusions about the content that you anticipated? Probe about the response.
  - a. If yes, (and there was a plan), how did your plan for addressing the confusions work?
  - b. If yes (and there wasn't a plan), how did you address them?
  - c. If no (regardless of plan), why do you think they learned the content so easily. (Observers: note that one possible reason the teacher could think 'no' is a lack of formative assessment/idea surfacing).
3. Do you think students met your goals for the lesson? How do you know?

## APPENDIX G

### TEACHER MONTHLY REFLECTION (TMR) SURVEY

Source: tmr-1 codebook.oo3

2008-08-29 6:06:20 PM 3/6

**1.0 In the last month, how often have you done (or attempted) each of the following in your target class? (We do not mean to imply that you "ought" to be doing any or all of these things!)**

1 = Never

2 = Once

3 = More than once, less than weekly

4 = Weekly or more, less than daily

5 = Daily

1.1 Used your classroom response system (CRS)

1.2 Used CRS to check students' understanding of a topic or concept that has already been covered

1.3 Used CRS to elicit students' ideas about a topic or concept that has not yet been addressed in class

1.4 Used CRS to have students wrestle with a question so they'd learn from the Experience

1.5 Used CRS to make a specific point (about subject matter, learning, or anything else)

1.6. Posed a CRS question about something other than subject-matter content (e.g., voting for a class activity, asking about everyday experiences or opinions)

1.7 Posed a CRS question at the beginning of class, before starting the day's Lesson

1.8 Collected answers to the same CRS question a second time, after discussing (in pairs or whole-class) the responses collected on the first pass

1.9 Invented and posed a CRS question "on the fly"

1.10 Altered your plan for the current lesson based on something you learned through CRS use

1.11 Revised your plan for a future lesson based on something you learned through CRS use

1.12 Designed multiple options or possibilities into a lesson plan, and used CRS to decide during class which one to follow

**2.0 When you "did" a CRS question during the last month in your target class, what fraction of the time did you include each of the following as part of that?**

1 = less than 25%

2 = 26% to 50%

3 = 51% to 75%

4 = 76% to 90%  
5 = more than 90%

- 2.1 Have students discuss answers to a CRS question with other students with neighbors, in pairs, or in small groups before sending answers via clickers
- 2.2 Facilitate whole-class discussion of students' ideas based on a CRS histogram

**3.0 Day-to-day, what aspect(s) of using CRS+TEFA have you been most focused on or concerned about during the last month? That is, which most demand your attention?**

[text](#)

**4.0 Within the last month, have you tried anything new in your teaching with CRS +TEFA?**

1 = No

2 = Not sure

3 = Yes, a little

4 = Yes, a lot

[comment] If so, please briefly describe what.

[text](#)

**5.0 Within the last month, is there anything related to CRS+TEFA that you've thought about trying but decided not to?**

1 = No

2 = Not sure

3 = Yes, a little

4 = Yes, a lot

[comment] If so, please describe what it was and why you didn't try it.

[text](#)

**6.0 How comfortable are you with each of the following aspects of practicing TEFA?**

1 = Very uncomfortable

2 = Somewhat uncomfortable

3 = Somewhat comfortable

4 = Very comfortable

6.1 Operating the technology

6.2 Creating (or borrowing/finding, choosing, and adapting) CRS

Questions

6.3 Implementing the "question cycle" (pose, think/talk, answer, histogram, share, discuss)

6.4 Stimulating and steering good whole-class discussion

6.5 Figuring out what students think and why they think it

6.6 Adapting teaching based on info from CRS and discussion

[comment] Other aspects (if necessary):

[text](#)

**7.0 To what degree have each of the following possible barriers hindered your ability to practice TEFA the way you would have liked to this past month?**

- 1 = Not a barrier (no issue)
- 2 = Small barrier (inconvenience)
- 3 = Moderate barrier (limitation)
- 4 = Large barrier (prevents)

- 7.1 Insufficient technology or equipment available
- 7.2 Insufficient technical support available
- 7.3 Technology-related problems or bugs
- 7.4 Your ability to operate CRS reliably
- 7.5 Lack of prep time to plan curriculum/lessons integrating TEFA
- 7.6 Lack of class time to use TEFA
- 7.7 Difficulty creating or finding suitable TEFA questions
- 7.8 Difficulty reconciling TEFA with the rest of your teaching
- 7.9 Students' ability to use CRS clickers reliably and responsibly
- 7.10. Students' attitudes towards TEFA
- 7.11 School administrators' attitudes towards CRS, TEFA, and "the project"
- 7.12 Parents' attitudes towards CRS, TEFA, and "the project"

**8.0 What barriers or limitations, if any, most inhibited your ability to teach with CRS+TEFA this past month?**

[text](#)

**9.0 Within the last month, have you overcome any obstacles or limitations (external or internal) that had previously inhibited your ability to use CRS+TEFA?**

- 1 = No
  - 2 = Not sure
  - 3 = Yes, few and minor
  - 4 = Yes, many and major
- [comment] If so, what are they?

[text](#)

**10.0 In the previous question, if you identified any obstacles or limitations that you have overcome, what factors helped you make that progress?(Realizations, ideas, suggestions, experiences, etc.)**

[text](#)

**11.0 In the last month, have you observed any positive effects from using CRS +TEFA?**

- 1 = No

2 = Not sure  
3 = Yes, weak positive effect  
4 = Yes, strong positive effect  
[comment] If so, please describe them briefly.

[Text](#)

**12.0 In the past month, have you observed any negative effects from using CRS +TEFA?**

1 = No  
2 = Not sure  
3 = Yes, weak negative effect  
4 = Yes, strong negative effect  
[comment] If so, please describe them briefly.

[text](#)

**13.0 How do you rate each of the following aspects of your students' participation in discussions of CRS questions and responses (in your target class, during the last month)?**

1 = Poor  
2 = Basic  
3 = Good  
4 = Excellent

13.1 The overall quality, depth, and extent of students' contributions

13.2 Participation by "traditionally high-achieving students"

13.3 Participation by "traditionally middle-achieving students"

13.4 Participation by "traditionally low-achieving students"

[comment] Comments (optional):

[Text](#)

**14.0 Overall, how do your students seem to feel about using CRS+TEFA?**

1 = Very negative  
2 = Somewhat negative  
3 = Neutral or mixed  
4 = Somewhat positive  
5 = Very positive  
[comment] Comments (optional):

[text](#)

**15.0 In a few to several sentences, please describe how you ended up integrating TEFA into your target class in the past month. (How did you decide which days to use it? Which units, activity types, etc. did you use it in/for? What purposes did it serve? How did the actuality differ from your intentions? Etc.)**

[text](#)

**16.0** In a few to several sentences, please describe how you ended up integrating TEFA into your target class in the past month. (How did you decide which days to use it? Which units, activity types, etc. did you use it in/for? What purposes did it serve? How did the actuality differ from your intentions? Etc.)

text

**17.0** In a few to several sentences, please describe how you intend to integrate TEFA into your target class in the upcoming month. (How will you decide which days to use it? Which units, activity types, etc. will you use it in/for? What purposes will it serve? Etc.)

text

**18.0** If you wish to add any other comments about your experiences teaching with CRS+TEFA this past month or your feelings about it at present, you are welcome to do so here.

text

## BIBLIOGRAPHY

- Ackland, R. (1991). A review of the peer coaching literature. *The Journal of Staff Development, 12*(1), 22-27.
- Altrichter, H., Kemmis, S., McTaggart, R., & Zuber-Skerritt, O. (2002). The concept of action research. *The Learning Organization, 9*(3), 125-131.
- Altrichter, H., Posch, P., & Somekh, B. (1993). *Teacher investigate their work: An introduction to the methods of action research*. London: Routledge.
- Angers, J., & Machtes, K. (2005). An ethnographic-case study of beliefs, context factors, and practices of teachers integrating technology. *The Qualitative Report 10*(4), 771-794. Retrieved May 18, 2007, from <http://www.nova.edu/ssss/QR/QR10-4/angers.pdf>.
- Ascione, L. (2006). Study: Ed tech has proven effective but more needs to be done for technology to reach its full potential in schools. *eSchool News online*. Retrieved Oct 27, 2006 from <http://www.eschoolnews.org/news/pfshowStory.cfm?ArticleID+6600&CFID+163407&C>.
- Augustine, N. (2005). Rising above the gathering storm: Energizing and employing America for a brighter economic future. Report presented before Committee on Energy and Natural Resources U.S. Senate, October 18, 2005, Washington, USA. Retrieved April 29, 2008 from The Office of Congressional and Government Affairs, The National Academies Website: [http://www7.nationalacademies.org/ocga/testimony/Gathering\\_Storm\\_Energizing\\_and\\_Employing\\_America.asp](http://www7.nationalacademies.org/ocga/testimony/Gathering_Storm_Energizing_and_Employing_America.asp).
- Barron, B. (2000). Achieving coordination in collaborative problem-solving groups. *The Journal of the Learning Sciences, 9*(4), 403-436.
- Baur, J., & Kenton, J. (2005). Towards technology integration in the schools: Why it isn't happening. *Journal of Technology Education, 13*(4), 519-546.
- Beatty, I., D., Leonard, W., J., Gerace, W., J., & Dufresne, R., J. (2006). Question driven instruction: Teaching science (well) with an audience response system. In Banks, D. A., (ED.), *Audience Response Systems in Higher Education: Applications and Cases*. Idea Group Inc., Hershey, PA.
- Beatty, I., D., Gerace, W., J., Feldman, A., & Leonard, W., J. (2008). Technology-enhanced formative assessment: An innovative approach to student-centered science teaching. Paper presented at the Annual Meeting of the Association for Science Teacher Education, St. Louis, Missouri.

- Beatty, I.D., Feldman, A., Leonard, W. J., Gerace, W., St. Cyr, K., Lee, H., & Harris, R. (2008). Teacher learning of technology-enhanced formative assessment. Paper presented at the Annual Meeting of the National Association of Research on Science Teaching, Baltimore, Maryland.
- Becker, J.M. (1996). *Peer coaching for improvement of teaching and learning*. Teachers Network. Retrieved on September 3 from <http://www.ecs.or/clearinghouse/13/15/1315.doc>.
- Bell, B & Cowie, B. (2001). The characteristics of formative assessment in science education. *Science Education*, 85(5), 536-53.
- Black, P. and Wiliam, D. (1998a) Assessment and classroom learning. *Assessment in Education: Principles, Policy & Practice*, 5(1), 7-74.
- Black, P. and Wiliam, D. (1998b) Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan*, 80(2), 139-144.
- Brewer, C. A. (2004). Near real-time assessment of student learning and understanding in biology courses. *BioScience*. 54(11), 1035-1039.
- Brickhouse, N. W. (1989). Teachers content knowledge about the nature of science and its relationship to classroom practice. Paper presented at the Annual Meeting of the American Educational Research Association (San Francisco, CA).
- Brickhouse, N. W. (1990). Teachers' beliefs about the nature of science and their relationship to classroom practice. *Journal of Teacher Education*, 41(3), 53-62.
- Brickhouse, N. W. (1991). What counts as success? Perspectives from practice and research. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (Lake Geneva, WI).
- Brickman, P. (2006). The case of the druid dracula: A directed "clicker" case study on DNA Fingerprinting. *Journal of College Science Teaching*, 36(2), 48-53.
- Calhoun, E.F. (2002). Action research for school improvement. *Educational Leadership*, 59(6), 18-27.
- Coffey, A., & Atkinson, P. (1996). *Making sense of qualitative data*. Thousand Oaks, CA: Sage.
- Conner, M.L., & Clawson, J. G. (eds.) (2004). *Creating a learning culture: Strategy, technology, and practice*. Cambridge University Press.

- Corcoran, T.B. (1995). Helping teachers teach well: Transforming professional development. CPRE Policy Briefs. Rutgers, NJ: Consortium for Policy Research in Education. Retrieved on March 12, 2006 from <http://www.nsd.org/standards/index.cfm>.
- Costa, A.L., & Garmston, R. J. (2002). *Cognitive coaching: A foundation for renaissance schools*(2<sup>nd</sup> ed.). Norwood, MA: Christopher-Gordon Publishers, Inc.
- Cowie, B., & Bell, B. (1996). Validity and formative assessment in the science classroom. Invited keynote paper to Symposium on Validity in Educational Assessment, 28–30 June, Dunedin, New Zealand.
- Crawford, C. M. (2000). Impacting learning environments for PreKindergarten through graduate school: Technologically appropriate professional development and classroom integration opportunities for educators. In: Proceedings of SITE 2001: Society for Information Technology and Teacher Education International Conference (Orlando Florida) ERIC Digest, 124 (ERIC Document Reproduction Service No. ED 427 820)
- Cuban, L., Kirkpatrick, H., & Peck, C. (2006). High access and low technology usage in high school classrooms: Explaining the apparent paradox. *American Educational Research Journal*, 38(4), 813- 834.
- Danielson, C. (1996). Enhancing professional practice: A framework for Teaching. Virginia: Association for Supervision and Curriculum Development (ASCD).
- Demographics. Retrieved May 3, 2007, from <http://www.schoolmatters.com/app/location/q/stdid=22/llid=118/stllid=320/locid=975438/catid=-1/secid=-1/compid=-1/site=pes>
- Dillon, J., Osborne, J., Fairbrother, R., & Kurina, L. (2000). A study into the professional view and needs of science teachers in primary and secondary schools in England, London. London: King's College.
- Dewey, J. (1902). *The child and the curriculum*. Chicago: University of Chicago Press.
- Dewey, J. (1916). *Democracy and education: An introduction to the philosophy of education*. New York: Free Press.
- Dewey, J. (1924). *Democracy and education*. New York: Macmillan Company.
- Dewey, J. (1929). *The sources of a science education*. New York: Haorace Liveright.
- Dufresne, R., J., Gerace, W., J., Leonard, W., J. Mestre, J., P. & Wenk, L. (1996). ClassTalk: A classroom communication system for active learning. *Journal of Computing in Higher Education*, 7: 3-47.

- Dufresne, R., J., Gerace, W., J., Mestre, J., P. & Leonard, W., J. (2000). ASK-IT/A2L: Assessing student knowledge with instructional technology. Technical Report Dufresne-2000aia, University of Massachusetts Scientific Reasoning and Research Institute.
- Earle, R. S. (2002). The integration of instructional technology into public education: Promises and challenges. *Educational Technology*, 42(1), 5-13.
- Ertmer, P. A. (1999). Addressing first and second order barriers to change: Strategies for technology integration. *Educational Technology Research & Development*, 47(4), 47-61.
- Ertmer, P.A. (2005) Teacher pedagogical beliefs: The final frontier in our quest for technology? *Educational Technology Research and Development*, 53(4), 25-29.
- Evans, L. (2002). What is teacher development? *Oxford Review of Education*, 28(1), 123-137.
- Eylon, B., Berger, H., & Bagno, E. (2007). An evidence-based continuous professional development programme on knowledge integration in physics: A study of teachers' collective discourse. *Paper submitted to The International Journal of Science Education*.
- Feldman, A. (1999). Decision making in the practical domain: A model of practical conceptual change.
- Feldman, A. (2002). Existential approaches in action research. *Educational Action Research*, 10(2), 233-252.
- Feldman, A. (2007). Validity and quality in action research. *Educational Action Research*, 15(1), 21-32.
- Feldman, A., & Capobianco, B. (2000). Action research in science. ERIC Digest, ERIC ID: ED463944.
- Feldman, A., & Capobianco, B. (2007). Teacher learning of technology enhanced formative assessment. JOST Tracking Number: JOST Manuscript (2007-45-Feldman) final version accepted for publication.
- Feldman, A., & Minstrell, J. (2000). Action research as a research methodology for the study of the teaching of and learning of science. In E. Kelly & R. Iesh (Eds.), *Handbook of research design mathematics and science education*. Mahwah, NJ: Lawrence Erlbaum Associates.

- Feldman, A., Paugh, P., & Mills, G. (2004). *Self-study through action research* in the International Handbook of Self-study of Teachers Educational Practices. Netherlands: Klumer Academic Publisher.
- Fies, C., & Marshall, J. (2006). Classroom response systems: A review of the literature. *Journal of Science Education and Technology*, 15(1), 101-109.
- Fischer, J. M., Hamer, L., Zimmerman, A. S., Samel, A., Long, L., & McArthur, J. (2004). The unlikely faces of professional development in urban schools: preparing at risk students and colleges for one another. *Educational Horizons*, 82(3), 203-212. Retrieved December 11 from ERIC (ERIC Document Reproduction Service No. EJ684785).
- Fleming, D. S. (2000). *The AEL guide to action research*. Charleston, WV: Appalachian Education Laboratory.
- Fraser, C.A. (2005). Towards a unified model of professional development? University of Aberdeen. Retrieved February 25, 2007 from <http://www.abdn.ac.uk/cass/pgradconf/papers/ChristineA.Fraser.pdf>
- Gatsby Technical Education Projects (GTEP). (2006). *Continuing professional development through portfolios of evidence: accomplished science teaching in six domains*. Gatsby Technical Education Projects, London.
- Goldenberg, C., & Gallimore, R. (1991). Changing teaching takes more than a one-shot workshop. *Educational Leadership*, 49(3), 69-72.
- Goldhammer, K. (1980). An agenda for Education for the Next Generation. Retrieved on August 12, 2006 from ERIC, ERIC ID: ED194501.
- Guadelli, W. (2002). Professional development, global pedagogy, and potential: Examining an alternative approach to the episodic workshop. Paper presented at the annual Meeting of the National Council for Social Studies (Washington, DC) ERIC Digest, 124 (ERIC Document Reproduction Service No. ED 463 210).
- Gudmundsdottir, S., & Shulman, L (1987). Pedagogical content knowledge in social studies. *Scandinavian Journal of Educational Research*, 31, 59-70.
- Gudmundsdottir, S. (1995). The narrative nature of pedagogical content knowledge. In H. McEwan and K. Egan (Eds.), *Narrative in teaching, learning, and research* (pp.24-38). New York: Teachers College Press.
- Guskey, T. R. (1994). Results-oriented professional development: In search of an optimal mix of effective practices. *Journal of Staff Development*, 15(4), 42-50.

- Guskey, T. R. (2000). Evaluating professional development. Thousand Oaks, CA: Corwin Press. (Chapter 3: Practical Guidelines for Evaluating Professional Development).
- Guskey, T. R. (2002). Professional development and teacher change. *Teachers and Teaching: Theory and Practice*, 8(3/4), 391-391.
- Guskey, T. R. (2003, April). The characteristics of effective professional development. Paper presented at the Annual Meeting of the American Educational Association (AERA) (84<sup>th</sup>, Chicago, IL, 21-25).
- Guskey, T. R. (2003). Analyzing lists of the characteristics of effective professional development. *National Association of Secondary School Principals. NASSP Bulletin*, 87(637), 4-21.
- Guskey, T. R., & Sparks, D. (1991). What to consider when evaluating staff development. *Educational Leadership*, 49(3), 73-76.
- Haney, J.J., Lumpe, A.T., & Czerniak, C.M. (2003). Constructivist beliefs about the science classroom learning environment: P *School Science and Mathematics*, 103(8), 366-377.
- Hargreaves, A., & Dawe, R. (1990) Paths of professional development: Contrived collegiality, collaborative culture, and the case of peer coaching. *Teacher and Teacher Education*. 6(3), 227-241.
- Hatch, J., Jenson, M., & Moore, R. (2005). Manna from heaven or “clickers” from hell: Experiences with an electronic response system. *Journal of College Science Teaching*, 36-39.
- Hernandez-Ramos, P. (2005). If not here, where? Understanding teachers’ use of technology in Silicon Valley schools. *Journal of Research on Technology in Education*, 38(1), 39-64.
- Herreid, C. F. (2006). “Clicker” cases: Introducing case study teaching into large classrooms. *Journal of College Science Teaching*, 43-47.
- Hokanson, B., & Hooper, S. (2004). Integrating technology in classrooms: We have met the enemy and he is us. Paper presented at the 27<sup>th</sup> Annual Meeting of the Association for Educational Communications and Technology (Washington, DC) ERIC Digest, (ERIC Document Reproduction Service No. ED 485 143).

- Irving, K., E., Sanalan, V., A., & Shirley, M., L. (2008). Technology-facilitated formative assessment in physical science connected classrooms: Case studies. Paper presented at Annual Conference of the Association of Science Teacher Education (ASTE) Missouri, USA. Retrieved February 2, 2008 from <http://www.ccms.osu.edu/ASTE2008/PDFForScience.pdf>.
- Johnson, C. C., Butler Kahle, J., & Fargo, J. D. (2007). A study of the effect of sustained, whole-school professional development on student achievement in science. *Journal of Research in Science Teaching*, 00 (0), 1-12.
- Johnson, D., & Mcleod, S. (2004). Get answers: Using personal response systems to see students' thinking. *Learning & Leading with Technology*, 32(4), 18-23.
- Joyce, B., & Showers, B. (2002). *Student achievement through staff development*(3<sup>rd</sup> ed.). Alexandria, VA.: Association for Supervision and Curriculum Development.
- Keeler, A. (2006). Classroom performance system (CPS). *Media and Methods*, 42(2), 35.
- Killion, J. P. (1990). The benefits of an induction program for experienced teachers. *Journal of Staff Development*, 11(4), 32-36.
- Killion, J. . (1999). *What works in the middle: Results-based staff development*. Oxford, OH:National Staff Development Council.
- King, D. (2007). Teacher beliefs and constraints in implementing a context-based approach in chemistry. *Teaching Science*, 53(1), 14-18.
- Kohler, F.W., Crilley, K. M., & Shearer, D.D. (1997). Effects of peer coaching on teacher and student outcomes. *Journal of Educational Research*, 90, 240-250.
- Kutlek, L.M., & Earnest, G.W. (2001). Supporting professional growth through mentoring and coaching. *Journal of Extension*, 39(4).
- Lave, J. (1988). *Cognition in practice: mind, mathematics and culture in everyday life (learning in doing)*. Cambridge University Press.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation (learning in doing: social, cognitive & computational perspectives)*. Cambridge University Press.
- Leonard, W.J., Gerace, W., Beatty, I., & Feldman, A. (2004). Teacher Learning of Technology-Enhanced Formative Assessment, University of Massachusetts Amherst. Proposal TLT, NSF TPC-0456124 submitted to 2004 NSF TPC Program.

- Levin, T., & Wadmany, R. (2007). Teachers' beliefs and practices in technology-based classrooms: A developmental view. *Journal of Research on Technology in Education*, 39(2), 255-281.
- Linehan, P., Müller, E., & Cashman, J. (2005, June). *Communities of practice: Activities sponsored by the Office of Special Education Programs*. (Synthesis Brief). Alexandria, VA: Project FORUM, National Association of State Directors of Special Education. Retrieved November 25, 2007, from <http://www.nasdse.org/publications/Communities of Practice Activities Sponsored by the Office of Special Education Programs.pdf>
- Linn, M.C., Philip Bell, P., & Davis, E.A. (2004) *Internet environments for science education*. New Jersey: Lawrence Erlbaum Associates, Inc.
- Little J.W. 1993. Teachers' professional development in a climate of educational reform. *Educational Evaluation and Policy Analysis* 15(2):129–52.
- Locke, L.F., Silverman, S.J., & Spirduso, W.W. (2004). *Reading and understanding research*. Thousand Oaks, CA: Sage.
- Loucks-Horsley, S., Hewson, P. W., Love, N. & Stiles, K. E. (1998). *Designing professional development for teachers of science and mathematics*. California: Corwin Press, Inc.
- Lumpe, A.T., & Chambers, E. (2001). Assessing teachers' context beliefs about technology use. *Journal of Research on Technology in Education*, 34(1), 93-107.
- Massachusetts 2001 State Plan for Professional Development – Massachusetts Department of Education. (2001). <http://www.doe.mass.edu/pd/stateplan>.
- McChesney, J. (1998). Whole-school reform. ERIC Digest, 124 (ERIC Document Reproduction Service No. ED 427 388).
- McCutcheon, G., & Jung, B. (1990). Alternative perspectives on action research. *Theory Into Practice*, 29(3), 144-151.
- McQuin, D. (2004). Test DRIVE: Classroom performance system. *School Library Journal*, 50(5), 31-45.
- Merriam, S. B. (1992). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.
- Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: a review of literature. *Journal of Information Technology for Teacher Education*, 9(3), 319-341.

- NSDC National Staff Development Council. (n.d.) *NSDC resolutions*. Retrieved May, 13, 2007 from <http://www.nsd.org/connect/about/resolutions.cfm>
- NSDC National Staff Development Council (Revised, 2001). Standards for Staff Development. Retrieved April 2, 2006, from <http://www.NSDC.org/standards/learningcommunities.cfm?printpage=1&>.
- NSDC National Staff Development Council. Standards for Learning Communities. Retrieved June, 10, 2007 from <http://www.nsd.org/standards/learningcommunities.cfm>.
- National Science Foundation (2006a). *Science and Engineering Indicators, Chapter 1 Elementary and Secondary School*. Retrieved Oct 11, 2006, from <http://www.nsf.gov/statistics/seind06/c1/c1h.htm#c1h1>.
- National Science Foundation (2006b). *National Science Foundation Investing in America's Future: Strategic Plan FY 2006-2011*. Retrieved April 27, 2008, from <http://www.nsf.gov/pubs/2006/nsf0648/NSF-06-48.pdf>.
- Odell, S. J. (1990) *Mentor teacher programs: What research says to the teacher*. Washington, D.C.: National Education Association.
- Ornstein, A. C. (1995). Beyond effective teaching. *Peabody Journal of Education*, 70, 2-23.
- Page, M. L., Rudney, G. L., & Marxen, C. E. (2004). Leading preservice teachers to water ... and helping them drink: How candidate teachability affects the gatekeeping and advocacy roles of teacher educators. *Teacher Education Quarterly*, 31(2), 25-41.
- Perkins, S. J. (1998). On becoming a peer coach: Practices, identities, and beliefs of inexperienced coaches. *Journal of Curriculum and Supervision*, 13(3), 235-254.
- Ponte, P., Ax, J., Beijaard, D., & Wubbels, T. (2004). Teachers' development of professional knowledge through action research and the facilitation of this by teacher educators. *International Journal of Research*, 20(6), 571-588.
- Rosenberg, M. J. (2004). The real and appropriate role of technology to create learning culture. In Conner, M. L., & Clawson, J. G. (eds.), *Creating a learning culture: Strategy, technology, and practice*. Cambridge University Press.
- Rossmann, G., & Rallis, S. (2003). *Learning in the field: An introduction to qualitative Research*. Thousand Oaks, CA: Sage.
- Saint-Onge, H., & Wallace, D. (2003). *Leveraging communities of practice for strategic advantage*. Boston: Butterworth-Heinemann.

- Sanalan, V., A., Irving, K., E., Pape, S., J., & Owens, D., T. (2008). A multi-faceted professional development program for science teachers: Classroom connectivity technology. Paper presented at Annual Conference of the Association of Science Teacher Education (ASTE) Missouri, USA Retrieved February 2, 2008 from <http://www.ccms.osu.edu/ASTE2008/PSCaseStudy.pdf>.
- Showers, B. (1984). *Peer coaching and its effect on transfer of training*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.
- Showers, B. & Joyce, B. (1996). The evolution of peer coaching. *Educational Leadership*, 53(6), 12-16.
- Shulman, S. (1987). Knowledge and teaching: Foundations of new reform. *Harvard Educational Review*, 57(1), 1-22.
- Shulman, S. (1990, April). Distinguished contribution to educational research (1989): Recipient's address. Presented at the meeting of the American Educational Research Association, Boston
- Shultz, R. (2005). The practicum: More than practice. *Canadian Journal of Education*, 28(1/2), 147-167.
- Simpson, M. (1999). Using information and communications technology as a pedagogical tool: Who educates the educators? *Journal of Education for Teaching*, 25(3), 247-262.
- Skiba, D. J. (2006). Got large lecture hall classes? Use clickers. *Nursing Education Perspectives*, 27(5), 278-280.
- Snyder, W. M. & Wenger, E. (2004). Our world as a learning system: a communities-of-practice approach. In Conner, M. L., & Clawson, J. G. (eds.), *Creating a learning culture: Strategy, technology, and practice*. Cambridge University Press.
- Somekh, B. (2006). *Action research: A methodology for change and development*. Open University Press.
- Sparks, D. (1994). A paradigm shift in staff development. *Journal of Staff Development*, 15(4), 26-29.
- Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures and developing grounded theory*.
- Sugar, W., Crawley, F., & Fine, B. (2004). Examining teachers' decisions to adopt new technology. *Educational Technology and Society*, 7(4), 201-213.

- Supovitz, J.A., & Turner, H.M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching*, 37, 963-980.
- Taitelbaum, D., Mamlik-Naaman, R., Carmeli, M., & Hofstein, A. (2007). Evidence of teachers' change while participating in a continuous professional development (CPD) programme and implementing the inquiry approach in the chemistry laboratory. *In print in: The International Journal of Science Education Dec 2007*.
- Tayeb, M. E., & Schneegans, S. (Eds.). (2005). *UNESCO Science Report 2005*. Paris, France: UNESCO Publishing.
- US Department of Energy (2008). *Teaching and Education*. Retrieved April 27, 2008 from US Department of Energy Website at <http://www.doe.gov/sciencetech/education.htm>.
- Veen, W. (1993). The role of beliefs in the use of information technology: Implications for teacher education, or teaching the right thing at the right time. *Journal of Information Technology for Teacher Education*, 2(2), 139-153.
- Wenger, E. (1999). *Communities of practice: learning, meaning and identity*. Cambridge University Press.
- Wenger, E. (2001). *Supporting communities of practice: A survey of community-oriented technologies*. Retrieved October 30, 2006 from <http://ewenger.com/tech/>.
- Wenger, E., McDermott, R., & Snyder, W. M. (2002). *Cultivating communities of practice: A guide to managing knowledge*. Boston, MA: Harvard Business School Press.
- Wong, K., & Nicotera, A. (2003). *Enhancing teacher quality: Peer coaching as a professional development strategy. A preliminary synthesis of literature*. Vanderbilt.
- Wood, E., Mueller, J., Willoughby, T., Specht, J., & Deyoung, T. (2005). Teachers' perceptions: barriers and supports to using technology in the classroom. *Education, Communication & Information*, 5(2), 183-206.
- Yin, R., K. (2003a). *Case study research: Design and methods*. Thousand Oaks, CA: Sage.
- Yin, R., K. (2003b). *Applications of case study research*. Thousand Oaks, CA: Sage.