EXAMINING THE INFLUENCE OF LEARNER-CENTERED PROFESSIONAL DEVELOPMENT ON ELEMENTARY MATHEMATICS TEACHERS' INSTRUCTONAL PRACTICES, ESPOUSED PRACTICES AND EVIDENCE OF STUDENT LEARNING

by

ANDREW BRET POLLY

(Under the Direction of Michael J. Hannafin)

ABSTRACT

This study examined the extent to which two elementary teachers' classroom practices were aligned with their intentions, self-reported implementation, and the practices emphasized during ongoing learner-centered professional development (LCPD) program designed to the support the integration of learner-centered mathematical tasks and associated pedagogies. Evidence of student activity associated with enactments was also examined.

Data were collected related to intended (i.e., what they planned to do), enacted (i.e., what they were observed doing), and espoused practices (i.e., what they believed they did). Teachers were observed when they indicated their intent to implement practices consistent with the professional development instructional practices and were interviewed to identify their intended and espoused practices.

Task enactments were taken directly from professional development activities (direct adoption), co-planned with project personnel, or independently planned by the teacher-participants. The Video Analysis Tool (VAT) was used to code instances of the six professional development instructional practices (i.e., tasks, questions, algorithms, technology, student communication, and mathematical representations) using a scale that codified the extent to which they implemented the pedagogies. Interview data were analyzed using the same instructional practices as primary codes.

Findings indicated that the majority of enactments did not align with the professional development instructional practices. Enactments and instructional practices were more consistent with the professional development pedagogies when professional developers scaffolded the tasks, but even highly scaffolded tasks were often implemented didactically. Evidence also suggested that instruction became increasingly learner-centered as the professional development progressed. Latter enactments included more learner-centered attributes than at the beginning of the study, though relatively few were observed. Learner-centered enactments included more student-generated mathematical representations, communication about mathematical thinking and sharing of mathematical work through various representations (e.g., using manipulatives, tables, computations).

Further research is needed to examine the influence of on-site support during teachers' enactments, changes in teacher practice, and the alignment among intentions, self-reports, and actual practices. Design experiments might better refine and modify professional development programs using ongoing, real-time evidence of teacher and student performance. Finally, research is needed to further explore and establish links among teacher learning, classroom implementations, and student learning.

INDEX WORDS: Professional development, learner-centered, mathematical tasks, elementary school education

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by

ANDREW BRET POLLY

B.S., College of William and Mary, 1999

M.S., Old Dominion University, 2001

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by

ANDREW BRET POLLY

Major Professor: Michael J. Hannafin

Committee: Janette R. Hill
Denise S. Mewborn
Chandra H. Orrill
Thomas C. Reeves

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
December 2006

DEDICATION

I dedicate this work to the following people:

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- My friends who provided support during the past four years;
- My “Montague Moms,” Roy Turner, Mr. Walk and others who helped launch my career as a teacher;
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Chapter I

STATEMENT OF THE PROBLEM

Student Achievement in Mathematics

Analyses of large-scale mathematics assessments indicate that American students are underachieving in mathematics. These measures indicate that students are failing to reach benchmarks set by the American government as well as the achievement levels of students in other developed nations (National Center for Educational Statistics [NCES], 2000; 2004). The story is similar in Georgia, where student performance on the 4th grade mathematics section of the 2003 National Assessment for Educational Progress (NAEP) was five points below the national average (230 compared to 235). Further, 73% of the state's 4th graders scored below "proficient" compared to 68% nationwide (NCES, 2004).

Analyses of student scores on large-scale tests and teachers' self-reports of practice have identified specific instructional practices that influence student achievement. A correlation study showed a positive relationship between teachers' self-report that they emphasized higher-order thinking and hands-on activities during instruction and student performance on the 1999 NAEP mathematics test. Students whose teachers reported using those practices scored one-half a grade level higher than their peers (Milken Family Foundation, 2000). Another researcher reported a positive correlation between reported technology use by 4th graders to develop higher-order skills and scores on the 1996 NAEP mathematics test (Wenglinsky, 1998).

Scholars (Bransford, Sherwood, Hasselbring, Kinzer, & Williams 1990; Bransford, Brown, and Cocking, 2000; Cognition and Technology Group at Vanderbilt [CTGV], 1992, 1997; Hannafin, 1992; Jonassen & Reeves, 1996) and national educational organizations (CEO Forum, 2001; National Council for Teachers of Mathematics [NCTM], 2000; National Research Council, 1996; National Council of Teachers of English, 1996) advocate integrating technology in ways that develop both conceptual understanding and higher-order thinking skills—a shift toward learner-centered instruction. McCombs and Whisler (1997) described learner-centered environments as places where learners engage in complex and relevant activities, collaborate with their peers, and employ resources such as technology to collect, analyze and represent information. While these approaches have potential to impact student learning, evidence of their use in schools is limited (McCombs, 2001, 2003). Researchers examining the implementation of learner-centered activities have reported that teachers tend to implement pre-designed activities didactically by supplying rote algorithms for students to follow (CTGV, 1992; Doyle, 1988; Greeno, 1983). A recent synthesis of research indicated that numerous teacher factors, such as content knowledge, pedagogical content knowledge, beliefs and their interpretation of the curriculum influenced how learner-centered activities are enacted in classrooms (Remillard, 2005). To this end, teachers need support in order to implement leaner-centered activities effectively in their classroom (NPEAT, 2000a).

Mathematics and Learner-centered Tasks

The field of mathematics education has advocated learner-centered activities and investigative approaches to mathematics for nearly two decades (NCTM, 1989, 2000;

Schoenfeld, 1992). These learner-centered mathematical activities have been referred to as mathematical tasks (Henningsen & Stein, 1997; NCTM, 2000; Stein, Grover, & Henningsen, 1996). Mathematical tasks are critical to students' learning because "tasks convey messages about what mathematics is and what doing mathematics entails" (NCTM, 1991, p. 24).

Further, the use of technologies, such as calculators and spreadsheets has been recommended by the mathematics education field (NCTM, 2000). According to NCTM, using technology to complete learner-centered tasks provides students with mathematical power, which they define as, "An individual's abilities to explore, conjecture, and reason logically, as well as the ability to use a variety of mathematical methods effectively to solve non-routine problems" (NCTM, 1989, p. 5).

Professional Development's Role in Improving Student Learning

If teachers are expected to impact student learning through technology-rich tasks, teachers need opportunities to learn with and about technology, as well as how to integrate technology-enhanced activities into their classroom teaching (Culp, Honey and Mandinach, 2003; Sandholtz, Ringstaff, & Dwyer, 1997; Schrum, 1999). In the past decade, leaders in professional development have presented theoretical perspectives about how teachers learn (Cohen & Ball, 1999; Putnam & Borko, 2000; Richardson, 1996) and recommended principles for effective professional development programs (e.g., Guskey, 2003). These recommendations include:

- focusing on issues related to student learning (Hawley & Valli, 1999);
- allowing teachers to take ownership of their learning (Hawley & Valli, 1999; Loucks-Horsley, Love, Stiles, Mundry, & Hewson 2003);

- addressing specific content and pedagogies (Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996; Desimone, Porter, Garet, Yoon, & Birman, 2002);
- providing opportunities for teachers to reflect and learn from their own practice (National Partnership for Educational Accountability in Teaching [NPEAT], 2000a, 2000b; Putnam & Borko, 2000; Schon, 1983);
- allowing teachers to collaborate with each other and with project staff (Sparks & Hirsch, 2000); and
- providing ongoing and comprehensive activities (Loucks-Horsley et al., 2003; Richardson, 1996).

In essence, these documents call for professional development to support learner-centered approaches to teacher learning (Hawley & Valli, 1999, NPEAT, 2000a, 2000b).

In mathematics, promising approaches to learner-centered professional development instruction have been advanced. These learner-centered programs allowed teachers to focus on student learning by having them watch videos of their own classroom instruction (Sherin & van Es, 2005), examine student work samples (Carpenter, Fennema, & Franke, 1996; Fennema et al., 1996), and make instructional decisions based on their analysis of student work (Fennema et al., 1996; Schifter & Simon, 1992; Simon & Schifter, 1991). The QUASAR (Quantitative Understandings: Amplifying Student Achievement and Reasoning) project established school-based communities, where teachers collaborated with each other and university faculty to develop and implement reform-based curricula in their classroom (Silver, Smith, & Nelson, 1995; Silver & Stein, 1996). Each of these approaches provided teachers with the opportunity to take ownership of their learning as they designed and modified instruction for their students. Further, every project lasted over a year, providing teachers with sustained and on-going support. While these projects have provided insight into the influence of learner-centered professional development on both teachers' and students' learning, more research is needed to examine how teachers enact mathematical tasks into their classroom.

Multi-level Impact of Professional Development

According to Guskey (2000), professional development has the potential to impact learners on five levels: participants' reactions, participants' learning, organization support and change, participants' use of new knowledge and skills, and student learning outcomes. Typically, professional development research has focused mainly on participants' reactions (Level One) and learning (Level Two) (Borko, 2004; Guskey, 2000), such as by completing questionnaire regarding their reactions and perceptions about what has been learned. Recently, researchers have begun to expand the focus to address the impact of professional development on organization and school change (Level Three), participants' classroom practices (Level Four) and student learning outcomes (Level Five) (Carpenter, Fennema, & Franke, 1996; Fishman, Marx, Best, & Tal, 2003; Knezek & Christensen, 2004; Kubitskey, Fishman, & Marx, 2003). This shift is consistent with state and national policies, which have reinforced the importance of linking teacher professional development to student learning. The No Child Left Behind Act (NCLB, 2002) mandates that all federal funds dispersed for professional development require an examination of the program's influence on student achievement. Further, Georgia legislation has mandated that all professional development funds be allocated towards activities that are likely to impact student achievement. Georgia's *A*

Plus Education Reform Act of 2000: House Bill 1187 (Georgia House of Representatives, 2000) states that "where possible, staff and professional funds shall be used for activities that enhance the skills of certificated personnel and directly relate to student achievement."

Problem

The influence of professional development programs designed to support technology-rich mathematical tasks on teachers' instructional practices and their students' learning outcomes have not been studied comprehensively. Research methods often focus largely or solely on teacher's attitudes about professional development and perceptions of technology skills; rarely have researchers addressed how teachers apply their knowledge and skill in their instruction, or whether such practices influence student learning. Level four and five examination requires clearly defined goals as well as methods and instruments that link validated teaching practices emphasized during professional development, evidence of classroom implementation of such practices, and corresponding indicators of student performance (Guskey, 2000).

The limited amount of available professional development research related to learner-centered, technology-rich tasks suggests that the focus includes content, technology skill, classroom implementation, and combinations of each (Polly, Orrill, Ledford, & Bleich, 2005; Orrill, Calhoun, & Sikes, 2002). Stein, Grover, and Henningsen (1996) contend that teachers' understanding and use of mathematical tasks are influenced by their mathematical content knowledge, knowledge of students, and instructional habits. When tasks are technology-rich, teachers also need to create and maintain environments where technology can support mathematical learning.

While learner-centered approaches to professional development have been recommended (Hawley & Valli, 1999; NPEAT, 2000a, 2000b), empirical research is needed to examine how learner-centered professional development programs influence teachers’ classroom practices and their students’ learning. If provided with learner-centered opportunities to develop the knowledge and skills needed to effectively integrate technology-rich activities into their classroom, teachers may better influence their students’ learning.

Purpose of the Study

This study examined changes in mathematics beliefs and practices among elementary school teachers participating in a learner-centered, professional development program. The professional development program was designed to prepare participants to teach mathematics in an investigative manner, integrate technology-rich mathematical tasks into their classroom instruction, and attend closely to students’ mathematical thinking.

Three research questions guided this study:

1. *To what extent (and how) do teachers enact the practices emphasized in a learner-centered professional development during their mathematics teaching?*
2. *How do teachers’ enactments of the practices emphasized during learner-centered professional development compare with their espoused and intended practices?*
3. *How does evidence of student understanding reflect their teachers’ enacted practices?*

Chapter II

THEORETICAL FRAMEWORK

The focus on providing rich opportunities for teacher learning has increased in recent decades (Borko, 2005). While national organizations (e.g., National Staff Development Council [NSDC], 2001; National Partnership for Education and Accountability in Teaching [NPEAT], 2000a, 2000b) and leaders in professional development (e.g., Hawley & Valli, 1999; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003; Putnam & Borko, 2000; Sparks & Hirsch, 2000) have published recommendations for improving teacher learning, research studies documenting the impact of ongoing efforts are scarce. Research has primarily emphasized teacher perceptions of their professional learning opportunities rather than application to classroom instruction (Guskey, 2005).

In addition, despite spending billions of dollars on educational reforms in the past two decades, little evidence indicates that the financial investment made by states and the national government have increased student learning in America’s schools (National Center for Educational Statistics [NCES], 2000; 2004). Increasingly, contradictions have arisen about what constitutes student learning. Federal policies, such as the No Child Left Behind Act (NCLB, 2002) view scores on standards-based tests as the primary valid indicator of student learning. Meanwhile, standards published by national educational organizations (e.g., National Council of Teachers of Mathematics [NCTM], 1989, 2000; the National Research Council [NRC], 1996; National Council of Teachers of English

[NCTE], 1996) view both standards-based tests and performance-based tasks as valid evidence of student learning. Performance-based tasks could be used under NCLB, but the mandate to test every child limits its feasibility due to the time and cost involved in creating and scoring performance-based measures.

Further, academic standards increasingly call for teachers to establish learner-centered classrooms (McCombs & Whisler, 1997) that require learners to synthesize, analyze and evaluate information (NCTE, 1996), form and test conjectures (NCTM, 2000) and engage in inquiry-based activities (NRC, 1996). In mathematics, the NCTM (2000) *Principles and Standards* call for the implementation of instructional practices consistent with learner-centered tasks, assuming that student performance on both standards-based and performance-based assessments will improve. This argument is supported by research indicating a positive correlation between teachers' self-reported use of hands-on higher-order mathematical thinking tasks and students' mathematics scores on the 4^{th} grade 1999 National Assessment for Educational Progress (NAEP). However, despite correlation evidence of positive impact on student learning, fewer than 25% of teachers reported they used hands-on activities in their mathematics classrooms (Milken Family Foundation, 2000).

Learner-centered activities have the potential to increase student learning on measures of both standards-based and performance-based assessments. However, previous research indicates the need to identify effective ways to support teachers' use of these tasks. In the following, I argue for professional development programs that support the enactment of learner-centered activities in K-12 schools, and propose a research agenda that examines teacher learning as well as its impact on classroom practices and student learning.

Learner-Centered Tasks, Technology, and Student Learning: A Primer

Learner-centered classrooms gained prominence with the publication of the *American Psychological Association's Learner-Centered Principles* (APA, 1997). The American Psychological Association published the *Learner-Centered Principles for Instruction* (APA Work Group of the Board of Educational Affairs, 1997) in response to a need for research-based recommendations for educational reforms (Alexander & Murphy, 1998). This research base draws from the fields of educational psychology and psychology, and provides principles that should be considered when designing learning environments for K-adult learners (Alexander & Murphy, 1998). Subsequently, these principles have been adapted for K-12 learning and championed as a framework for educational reform (McCombs & Whisler, 1997; McCombs, 2001, 2003).

According to Doyle (1983), academic tasks focus on three facets of student's work: (a) products that students formulate, (b) process of generating the product and (c) resources available to students as they generate the product. Doyle concluded that learning tasks "are defined by the answers students are required to produce and the routes that can be used to obtain these answers" (p. 161). Consistent with Doyle's (1983) characterization, for purposes of this study, learner-centered tasks comprise instructional activities that are aligned with the *Learner-Centered Principles*. Based on McCombs and Whisler's (1997) work and the *Learner-centered Principles* (APA, 1997), Table 2.1 synthesizes the characteristics of learner-centered tasks.

Table 2.1: Characteristics of Learner-Centered Tasks (Adapted from McCombs & Whisler, 1997).

Task	Characteristic	Learner-centered tasks	Learner-Centered Principles (APA Work Group, 1997)
Design	Relevant	Personally relevant to students' lives and build upon prior experience or prior knowledge.	The learning of complex subject matter is most effective when learners construct meaning from information and experience (Principle 1). The successful learner can link new information with existing knowledge in meaningful ways (Principle 3). An individual's motivation is influenced by their beliefs and interests (Principle 7), the learner's creativity and curiosity (Principle 8), and their background and experiences (Principles 10, 12 and 13).
	Student-directed	Designed so that learners have ownership of the tasks they are completing, have, are able to choose their approach and have some influence about how the products of the task are represented.	An individual's motivation is influenced by their beliefs and interests (Principle 7), the learner's creativity and curiosity (Principle 8), and their background and experiences (Principles 10, 12 and 13).
	Reflective	Reflective and allow learners to refine their understanding and make connections between concepts or approaches used to complete the task.	Higher order strategies for selecting and monitoring mental operations facilitate creative and critical thinking (Principle 5).
	Assessment	Aligned with assessment so that learning is evaluated in the context of the task.	Setting appropriately high and challenging standards and assessing the learner as well as learning progress -- including diagnostic, process, and outcome assessment -- are integral parts of the learning process (Principle 14).
	Technology-rich	Able to be supported with technology that allows students to gather information, explore concepts, collaborate with peers or represent knowledge.	Learning is influenced by environmental factors, including culture, technology, and instructional practices (Principle 6).
Implementation	Facilitated	Facilitated by teachers or peers that model, scaffold student learning and facilitate the completion of the tasks.	The successful learner, over time and with support, can create meaningful, coherent representations of knowledge (Principle 2).
	Collaborative	Implemented in a manner that allows students to collaborate and share ideas with one another.	Social interactions, interpersonal relations, and communication with others all provide opportunities for learning (Principle 11).

Learner-centered tasks are relevant to learners, allowing them to create meaning from their experiences. In learner-centered tasks, students assume ownership of their learning by identifying questions, investigating phenomena, synthesizing information and representing their newly formed knowledge in products. Tasks can vary in complexity and difficulty and place different cognitive demands on students (Hiebert & Wearne, 1993). Thus, the teacher supports learner-centered tasks by modeling processes, scaffolding student knowledge construction, guiding thinking, and facilitating reflection as students evaluate what they learn.

Technology and Learner-Centered Tasks

Technology has been recommended as a resource to support learner-centered instruction (e.g., APA, 1997; Bransford, Brown, & Cocking, 2000; International Society for Technology in Education, 2000). Educational theorists have characterized technology as a tool to support learner-centered tasks (see Bransford et al., 2000, Cognition and Technology Group at Vanderbilt [CTGV], 1997; Hannafin, 1992; Jonassen & Reeves, 1996; McCombs, 2003; NRC, 2000; Papert, 1980). Apple Classrooms of Tomorrow (ACOT) researchers reported that teachers, as part of an extensive, multi-year professional development project, began integrating technology in their classrooms and their instruction shifted from a didactic to learner-centered (Sandholtz, Ringstaff, & Dwyer, 1997). ACOT students used technology to create products (e.g., instructional materials for other students), explore complex problems (e.g., determining how to conserve the world's energy sources), and examine real-world scenarios (e.g., planning a budget for a vacation).

While the potential to facilitate student learning is apparent, research on technology's impact on learning has yielded mixed results. Despite voluminous published research (e.g., Mann, 1999; Sandholtz, Ringstaff, & Dwyer, 1997; Ringstaff & Kelley, 2002; Roschelle, Pea, Hoadley, Gordin, & Means, 2001; Schacter, 1999; Wenglinsky, 1998), it has proven problematic for researchers to establish relationships between technology and student learning without accounting for the manner in which technology is used (Roschelle et al., 2001). Research indicates that technology impacts learning positively when associated with learner-centered activities, such as when students use technology to facilitate problem solving, conceptual development, and critical thinking (Cognition and Technology Group at Vanderbilt: CTGV, 1992; Means, 1994; Sandholtz, Ringstaff, & Dwyer, 1997; Ringstaff & Kelley, 2002; Wenglinsky, 1998).

Wenglinsky (1998) analyzed student's performance on the 1996 8^{th} grade National Assessment of Educational Progress (NAEP) mathematics test and found that students whose teachers reported using technology in conjunction with learner-centered pedagogies scored significantly higher than their peers whose teachers did not. Conversely, research also suggests possible detrimental technology effects when implemented didactically, such as focusing only on procedural knowledge rather than students' conceptual understanding. An analysis of the 2000 NAEP mathematics data indicated that 8th graders who used technology for mathematics drill and practice scored significantly lower than their peers who used no technology (NCES, 2000). Clearly, technology's impact on student learning varies according to the nature of the learning task and the manner in which it is used.

Dilemmas with the enactment of learner-centered tasks

Discrepancies between teachers' intended use and enactment of learner-centered tasks, common in the carryover of professional development programs to everyday teaching-learning practices, are both pervasive and significant. In science education, for example, the University of Michigan's Center for Learning Technologies in Urban Schools (LeTUS) project provided urban school districts in Detroit and Chicago with reform-based science curriculum and professional development to support the enactment of these materials. While multiple LeTUS studies have reported a high level of implementation based on teacher surveys and classroom observations (Fishman et al., 2003; Kubitskey et al., 2003), some teachers reverted to traditional approaches when confronted with time constraints, unfamiliar content, and problems with technology (Schneider, Krajcik, & Blumenfeld, 2005). LeTUS researchers reported that teachers complained about the extended time needed to complete their typical didactic science lessons. According to Doyle (1988), higher-level tasks, consistent with the learner-centered principles, are often more complex in nature and take longer to implement than traditional classroom activities. In such circumstances, teachers tended to supply answers or specify procedures to speed up students' task completion.

Teachers in the *Jasper Woodbury* project posed pre-designed tasks that required students to view an *adventure* on a video-disc, identify needed information, determine how to examine a task, and apply their solutions to an immediate sub-problem (CTGV, 1997). Classroom observations suggested that many teachers were reluctant to depend on the pre-packaged materials or allow their students to take responsibility for their learning (CTGV, 1992). Others modified Jasper tasks by providing drill-and-practice worksheets that addressed the same skills embedded in the video scenarios (CTGV, 1992). Some teachers even provided algorithms to solve Jasper's open-ended problems which were designed to promote student analysis, investigation, and problem solving skills.

Analyses of enacted learner-centered curricula. While numerous curriculum reforms have been designed to support learner-centered instruction, research indicates that teachers experience numerous problems enacting such curricula in their classrooms. Kim and Stein's (2006) analysis of two learner-centered mathematics curricula,implementations, *Investigations in Number, Data and Space* (TERC, 2004) and *Everyday Mathematics* (University of Chicago School Mathematics Project, 2004), showed that teachers' enactment became increasingly didactic in both cases. With the more learner-centered curriculum, *Investigations*, teachers posed numerous learner-centered tasks but provided explicit algorithms which students used to complete the task. In the case of *Everyday Mathematics*, a majority of the implementations included the same type of task (e.g. division by a 1-digit divisor); students used the same traditional algorithms repeatedly to complete the tasks.

Remillard (2005) analyzed 25 years of research on teachers' enactment of reform-based mathematics curricula across grade levels and found wide variations between the curricula author's intended use (referred to as *intended curriculum*) and its actual enactment in classrooms (referred to as *enacted curriculum*). Many factors influenced teachers' enactment of intended curricula, including pedagogical content knowledge, subject matter knowledge, beliefs, goals and experiences, capacity to design instruction, perception of curriculum, perception of their students, tolerance for student discomfort, and identity as a teacher. Clearly, while the design of learner-centered curricula can support the implementation of learner-centered instruction, they are not sufficient to ensure effective classroom implementation. Teachers need on-going support to develop the knowledge and skills necessary to successfully enact learner-centered tasks and positively influence student learning (Hawley & Valli, 1999; Loucks-Horsley et al., 2003). Research is needed to determine how to best support teachers' enactment of learner-centered curriculum in everyday classrooms.

Enactment of mathematical tasks. Doyle (1983, 1988; Doyle et al., 1985) observed teachers attempting to implement complex mathematical tasks found that teachers frequently simplified tasks to alleviate students' struggles and speed up task completion. Teachers modeled specific algorithms for their students and provided the procedures needed to solve the tasks. While students worked independently on mathematical tasks, the teacher explicitly linked the algorithms to the students' tasks and told them which procedures to use (Doyle et al., 1985). Doyle (1983) noted that assessments emphasized the content and procedures that were modeled and explained rather than the problem-solving skills the tasks were designed to promote.

Doyle et al. (1985) also noted that the number of tasks completed was largely unrelated to the amount of learning that occurred. Although the students completed numerous mathematical tasks, coverage was not expanded thus serving as a review rather than an extension of skills and concepts already learned. In effect, the tasks emphasized application of previously-learned algorithms or routinized procedures rather than novel work, in which students make decisions about how to approach and complete the tasks. In mathematics, multi-step problems require the student to choose which operations to use and which numbers to include in their work (Doyle, 1988).

The QUASAR project provided teachers with professional development opportunities to learn with, design, and implement worthwhile mathematical tasks in their classrooms (Henningsen & Stein, 1997). Researchers observed that teachers' enactment of mathematical tasks was influenced by their desire to avoid student frustration. In an effort to minimize frustration, they regressed to didactic, teacher-centered instruction:

> In many instances, teachers appeared to find it difficult to stand by and watch students struggle, and they would step in prematurely to relieve them of their uncertainty and (sometimes) emotional distress at not being able to make headway. All too often, however, teachers would do too much for their students, taking away students' opportunities to discover and make progress on their own. (Stein, Grover & Henningsen, 1996, p. 480)

Evidence from a wide range of studies underscores the variety of dilemmas teachers confront while enacting learner-centered tasks in their classrooms. Since teacher enactment influences both what and how students come to learn and understand mathematics, it is crucial to clarify the attributes of learner-centered instruction in both principle and practice, to prepare teachers in those principles and practices, and to document the connections between everyday classroom enactment and student learning. In the following section, we examine link between learner-centered principles and learner-centered professional development.

A Framework for Learner-Centered Professional Development

Table 2.2 lists six primary characteristics of learner-centered professional development (LCPD). These characteristics were identified by synthesizing recommendations for professional development (Guskey, 2003; Hawley & Valli, 1999; Loucks-Horsley et al., 2003; NPEAT, 2000a), APA's learner-centered principles (APA Work Group, 1997) and research studies on professional development projects. Table 2.3 identifies professional development programs that embody learner-centered characteristics, and Table 2.4 details the methods used and research findings reported from each program. [1]

Student-focused

According to the *Learner-Centered Principles* (APA Work Group, 1997) learners construct knowledge by associating information with their experiences (Principle 1). Further, Principle 2 posits that learning can be enhanced when students are guided and supported over time by others. The teacher can provide opportunities for learners to design, implement, and guide these learning experiences (McCombs & Whisler, 1997). A primary goal of professional development, therefore, should be to improve student learning (NPEAT, 2000a; Hawley & Valli, 1999). Professional development programs need to prepare teachers to design learner-centered tasks, examine students' work, identify problems students encounter, and guide students through the learning process (Hawley & Valli, 2000; Loucks-Horsley & Matsumoto, 1999).

The Cognitively-Guided Instruction (CGI) mathematics project (Carpenter, Fennema, & Franke, 1996; Fennema et al., 1996) focused on improving learning by having teachers examine students' mathematical thinking while completing mathematical tasks. CGI teachers watched video cases of students as they completed the tasks and discussed students' problem-solving processes. After examining the student's approaches to problem solving, teachers described how they could modify their instruction to design tasks that were appropriate to their students' cognitive development. When they returned to their classroom, teachers were expected to pose mathematical tasks, pose questions about students' mathematical thinking, analyze their students' approach to solving

[1] Tables 2.2, 2.3 and 2.4 are presented at the end of this chapter on pages 44-46.

problems, and use that information to design other appropriate tasks. Data collected from interviews and classroom observations indicated that CGI teachers began to adopt both the beliefs and instructional practices emphasized during the workshops. Researchers also examined student performance and found that students in classrooms where CGI teachers incorporated more appropriate mathematical tasks into their instructional practices scored higher on an assessment of problem-solving ability than students who did not (Carpenter et al., 1996). Further, while students in CGI classes scored comparably to control students initially, students who participated in CGI classes for two years scored significantly higher than students who had never been in a CGI classroom during the project's second year.

CGI was among the first professional development programs to link professional development to student achievement. The project staff developed a computation test and a problem-solving assessment, students were tested annually for three years, and scores were analyzed across teachers. Researchers also examined students' scores based on the length of time that students had been in CGI classrooms. Although the link between professional development and student learning is difficult to warrant due to the myriad factors, evidence tentatively suggests that teacher participation in the project may have improved student learning. In order to document the influence of professional development programs on student learning, it is important to link the instructional practices emphasized during professional development and teachers' enactment of those instructional practices with student learning outcomes that are aligned to those practices.

Teacher-owned

Principle 9 of the APA Work Group's (1997) learner-centered principles indicates that motivation is a key learning influence; motivation is also attributed in other APA principles to learners' beliefs and interests (Principle 7), creativity and curiosity (Principle 8), and background and experiences (Principles 10, 12 and 13). Loucks-Horsley et al. (2003) found that involving teachers in planning and selecting their professional development activities increased both their motivation to participate and the likelihood of classroom application. This pattern has been reported by other researchers who reported that teachers who chose their activities reported greater classroom implementation of than those who did not (Pink, 1992; Pink & Hyde, 1992).

However, ownership of learning can prove problematic: teachers are sometimes unaware of their own knowledge and skill needs (Borko & Putnam, 1995). Teachers surveyed and interviewed have reported that they prefer to participate in activities that can be applied immediately in their classroom over activities designed to develop their content knowledge (Wilson & Berne, 1999). However, learner-centered approaches often require both efforts to refine content and pedagogical content knowledge, as well as conceptual change about mathematics teaching, over an extended period of time (Fennema et al., 1996). Thus, learner-centered pedagogies may prove difficult or impossible to implement immediately without adequate support (e.g. CTGV, 1992; Fishman et al., 2003; Remillard, 2005; Schneider et al., 2005). Professional development programs need to attain a balance between what teachers want (i.e., promote teacher ownership, immediate classroom application) and what they need (i.e., reifying critical connections between teacher content and pedagogical content knowledge and student learning).

The LeTUS project staff developed learner-centered, technology-rich science units for teachers to use with middle school students. In one study, teachers implemented a pre-designed unit with a high degree of fidelity in Year 1. However, teachers reported that they needed additional opportunities to learn about the technology, the science content, and the tasks in order to implement the units effectively (Fishman et al., 2003). Year 2 professional development activities were revised accordingly to increase the time allotted for teachers to work with the content and technology. As a result, teachers reported increased sense of ownership of the units and the professional development program. Subsequent observations indicated that teachers applied the project's learner-centered pedagogy in the LeTUS unit as well as other science units (Fishman et al., 2003).

In the CGI mathematics project, staff provided guidance while teachers designed tasks; teachers designed and "owned" the mathematical tasks to be implemented in their classrooms (Fennema et al., 1996). However, task implementation varied. Some teachers implemented learner-centered tasks appropriate for students' cognitive level of mathematical thinking, while others implemented teacher-centered tasks that were not aligned with students' cognitive levels. The CGI team analyzed the implementation data in light of participants' reported beliefs. Using data from surveys, interviews, and classroom observations in an effort to align teacher's reports of mathematical beliefs to their implementation of CGI's practices, the research team concluded:

> Although the relation between levels of instruction and beliefs appears obvious, it was difficult to compare the relationships because a teacher's beliefs and instruction were not always categorized at the same level, and there was no

> overall pattern as to whether a teacher was at a higher level in beliefs or instruction. There was also no consistency in whether a change in beliefs preceded a change in instruction or vice versa (Fennema et al., 1996, p. 423)

These findings are consistent with previous research indicating the influence of teachers' beliefs on their instructional practices (Cooney, 1985; Franke et al., 1995 as cited in Fennema et al., 1996; Thompson, 1992). The CGI team suggested that teachers' change in practice could be attributed to "owning" the design and the enactment of the mathematical tasks in their classroom. In essence, teachers used their classroom as a "learning laboratory" (Fennema et al., 1996, p. 431).

Teacher ownership is critical to learner-centered professional development, as it increases the relevance of the activities. In the LeTUS project, designing professional development activities based on teacher's feedback led to a significant increase in student learning. The CGI research indicates that professional development needs to address teachers' beliefs that may vary from those advocated by or embodied in learner-centered professional development programs. Research is needed to identify factors influencing teachers' negotiation of their individual learning needs. To this end, we also need to study how professional developers support teachers as they attempt to enact the professional development practices in their classrooms.

Collaborative

According to Hargreaves (1997), learner-centered professional development programs should also develop a "culture of collaboration among teachers" (p. 1306). While some have described teachers as working in relative isolation (Lortie, 1975), contemporary views of knowledge construction suggest that teacher learning can be enhanced by allowing teachers to collaborate with colleagues in professional learning communities (e.g. Darling-Hammond, 1998; Putnam & Borko, 2000; Glazer & Hannafin, 2006). Consistent with APA's 11th learner-centered principle, "social interactions, interpersonal relations, and communication with others all provide opportunities for learning."

Researchers examining successful schools (Little, 1993) and school reform efforts (Bay, Reys, & Reys, 1999; Fullan, 1991) cite the importance of a collaborative environment. In professional development, numerous approaches to supporting collaboration have been advanced. ACOT (Ringstaff et al., 1996; Sandholtz et al., 1997) and CGI projects (Carpenter et al., 1996; Fennema et al., 1996) established collaboration in the workshops between project staff and teachers and also between the teachers themselves. Similarly, Glazer and Hannafin (2006) proposed a collaborative apprenticeship model in which a teacher-mentor guides a peer teacher through technology integration design and planning. Collaborative professional development embodies contemporary views that learning is situated in contexts, a social process, and distributed across activities, individuals and resources (Putnam & Borko, 2000).

The QUASAR project brought university professors, middle school teachers and school administrators together to design and implement learner-centered mathematics instruction consistent with the NCTM standards (NCTM, 1991, 2000). The project staff characterized teacher change and mathematics education reform as a "process that takes advantage of the synergy, support, and motivation supplied when a 'critical mass' of teachers undertakes reform for all students in a given school" (Stein & Brown, 1997, p. 156). QUASAR researchers documented several difficulties middle-school teachers encountered while implementing a learner-centered mathematics curriculum. Initially, teachers experienced problems modifying a traditional mathematics textbook; in subsequent project years, they used a learner-centered, reform-based curriculum but struggled during implementation due to a lack of content knowledge, an incomplete understanding of learner-centered pedagogies, and a district-wide emphasis on skills-based mathematics assessments. Implementation of learner-centered instruction did not improve until the third year, when the district's mathematics coordinator initiated co-planning meetings with the teachers. During their common planning time, the mathematics coordinator co-planned lessons based on the learner-centered curriculum and helped teachers locate materials and plan learner-centered instruction. Over time, the teachers collaborated with one another and rotated the responsibility to find resources and lead brainstorming sessions on ideas for lessons. Gradually, the mathematics coordinator withdrew her involvement, allowing the teachers to continue to collaborate but also have more ownership of their lesson planning. In effect, this provided teachers a collaborative apprenticeship where professional developers provided scaffolds to support the design and implementation of learner-centered instruction (Glazer & Hannafin, 2006).

Sherin and van Es' (2005; van Es & Sherin, 2002) work with video clubs also provided teachers with opportunities to collaboratively reflect on each other's mathematics teaching. By viewing videos together, teachers were able to compare their perspectives on videotaped practices with those of professional developers and peers. Teachers met after school to watch videos of each other's mathematics teaching. Following each video, teachers discussed both the tasks posed and teacher-student interaction, focusing on teacher questioning and students' mathematical thinking. The teachers then returned to their classroom and were charged to modify their teaching based on the pedagogies discussed during the video club. Collaboratively watching and sharing feedback during workshops increased the frequency with which teachers posed learner-centered tasks in their classrooms, facilitated student task completion via questioning, and interacted with students regarding their mathematical thinking and approaches (Sherin & van Es, 2005).

ACOT staff redesigned project activities for delivery in professional development centers located in schools where expert ACOT teachers worked. During the professional development, teachers learned about various pieces of technology, discussed approaches to integrating technology, observed the teaching of model technology-rich lessons, and co-planned and practiced teaching in a technology-rich classroom with the support of ACOT staff and expert teachers (Ringstaff & Yocam, 1994; Yocam & Wilmore, 1994). ACOT teachers also requested school-based support to help implement technology-rich lessons planned during the workshops. The initial peer collaboration *during* professional development was not available to support implementation when teachers returned to their classroom (Ringstaff et al., 1997). Rather than providing school-based support, the project emphasized purchasing equipment, providing professional development workshops, and conducting research.

Opportunities to collaborate are essential if teachers are to design and implement learner-centered tasks in their classrooms. Initiatives where project personnel apprentice teachers in the design and enactment of learner-centered tasks (Glazer & Hannafin, submitted; Stein & Brown, 1997) and teachers collaborate to critique and share ideas about teaching (Sherin & van Es, 2005) show promise. While teachers need school-based support in order to implement learner-centered tasks, collaboration may be neither feasible nor practical in many instances.

Comprehensive

According to the National Science Foundation's meta-analysis of Local Systemic Change through Teacher Enhancement Initiative, after 30 hours of professional development shifts in teachers' practice and impact on student learning should become apparent (Banilower, Boyd, Pasley, & Weiss, 2006). While this finding seemingly contradicts numerous multi-year studies in which the impact of professional development on teachers' practices and student learning does not appear until at least the second year (Fennema et al., 1996; Fishman et al., 2003; Silver & Stein, 1996; Stein & Brown, 1997), the disparity may be associated with the nature of the changes expected or required. To the extent professional development reifies, extends, and is aligned with teachers' existing beliefs and practices, less time and support may be needed to influence practice and student learning. To the extent substantial differences exist between current and professional development domain, epistemological and pedagogical knowledge, school culture, beliefs and practices, substantial time and support may be required (Fullan, 1991; Loucks-Horsley et al., 2003).

Learner-centered professional development programs need to provide sustained and comprehensive support for teachers as they enact new instructional practices in their classroom (Hawley & Valli, 1999; NPEAT, 2000a). Teacher learning authorities advocate multi-year programs (Richardson, 1990) that include a variety of learning opportunities (Loucks-Horsley et al., 2003); however, most professional development programs are limited in funding and rarely sustained (Garet, Porter, Desimone, Briman &

Yoon, 2001). Further, professional development is most effective when it is supported by and aligned to reforms and policies at the school, district and state levels (Fullan, 1995). Clearly, such support requires significant time and resources from professional developers and school personnel (Orrill, 2001; Richardson, 1990)

The LeTUS project (Fishman et al., 2003; Kubitskey et al., 2005), was part of a seven-year science reform effort between university researchers and an urban school district (Fishman et al., 2003). While LeTUS teachers enacted the curriculum at a high fidelity, teachers reported discomfort using the technology, specific instructional practices and their role as facilitators during the implementation. LeTUS personnel redesigned the professional development, so that workshops in year two focused more on increasing teacher's knowledge of content and comfort using technology and facilitating student's completion of the learner-centered tasks. In addition to teachers' enactment remaining high, student learning, which had only increased slightly in year one, improved significantly during the second year.

In the CGI project, teachers spent the first year learning about the project's rationale and the goal of supporting student's learning through learner-centered mathematical tasks and questioning strategies. While teachers posed tasks in their classroom, they were simultaneously learning how to design, support and enact associated practices. Thus, some teachers immediately modified their practices, while others did not substantially alter their teaching until year two. Further, analyses of student achievement data indicated that significant increases in student learning typically did not occur until the year following a significant change in instructional practices. Thus, teachers who modified practices during year one observed improvements in student achievement at the end of year two; those who did not change their practices until year two observed increases in student achievement at the end of year three (Fennema et al., 1996). Research is needed to examine the impact of learner-centered professional development programs across time. These studies can give insight to the amount of time in various professional development activities needed to effectively support teachers' implementation of the instructional practices emphasized in these programs.

Comprehensive professional development initiatives also call for numerous school personnel to be involved in the implementation of learner-centered curriculum. Research is needed to clarify both time and support needed to sustain implementation of learner-centered curriculum. After these factors have been identified, studies should be conducted to identify how professional development programs can influence these factors in a way that will support the implementation of learner-centered curriculum.

Content and pedagogically-based

Professional development on specific content and content-specific instructional practices has been found to change teacher practice and improve student learning (Garet et al., 2001; Kennedy, 1998). Desimone, Porter, Garet, Yoon, and Birman (2002) also found that teachers who participate in activities that focus on specific content or pedagogy (e.g., inquiry-based science activities, mathematical investigations, product-oriented history projects) reported higher adoption rates of associated instructional practices. According to an NCES survey of nearly 1,500 teachers, over half reported using standards-based activities to a great extent in their classroom (USDoE, 1998); of those who reported using standards-based classroom practices, 65% had participated in professional development focused on standards-based instruction.

Teachers also benefit from opportunities to develop content knowledge in their teaching field (Loucks-Horsley et al., 2003). This is especially evident in mathematics, where teachers' content knowledge and pedagogical content knowledge have been empirically linked to student learning (Hill, Rowan, & Ball, 2005). According to *APA Learner-Centered Principles* (APA Work Group, 1997), learning is most effective when learners construct meaning from information and experience (Principle 1), and is enhanced through guidance (Principle 2) and increased motivation (Principle 9). Learners, in turn, are motivated by activities aligned to their interests (Principle 7) and their personal experiences (Principles 10, 12 and 13). To this end, teachers need sustained opportunities to engage domain content, experience and adapt pedagogies, and enact and refine learner-centered classroom-relevant activities.

One approach to developing content knowledge involves having teachers participate as learners in tasks that resemble those they will implement in their classrooms (Loucks-Horsley et al., 2003). Professional development designed to support technology-rich, learner-centered tasks should give teachers the opportunity to use technology to complete these tasks while professional developers model the practices to be enacted in their classrooms. Further, these experiences should be customized to provide opportunities for teachers to consider how to implement these tasks with their own students. Hence, professional developers need to design and model tasks that deepen teachers' content and pedagogical content knowledge and will benefit their classroom teaching (Hawley & Valli, 1999).

The LeTUS project focused on integrating technology-rich, learner-centered science activities in middle school classrooms. LeTUS units were designed by the project staff and allowed students to use technology to address a driving question on a real-life scenario by gathering, examining, and synthesizing information. During professional development, teachers first engaged with the curricular materials as learners, while the LeTUS project staff modeled how to use technology, questioned teachers and led discussions that helped unpack the science content. In essence, the LeTUS staff explicitly mimicked the instructional practices that they wanted the teachers to enact in their own classroom (Blumenfeld, Fishman, Krajcik, Marx, & Soloway 2000). Upon completing the workshops, teachers reported feeling prepared to integrate LeTUS units into their teaching.

Unlike findings from the *Jasper* project, where some teachers used technology-rich learner-centered activities in a didactic manner (CTGV, 1997), most LeTUS units were enacted as modeled in the learner-centered professional development activities. Apart from minor adaptations, such as shortening the length of discussions, classroom observations indicated that the units were implemented very closely to their intent (Fishman et al., 2003). While high fidelity enactment could be attributed to the teachers' willingness to employ constructivist-based instructional practices, researchers suggested that fidelity was also influenced by the depth and detail of the supporting materials (Fishman et al., 2003; Kubitskey et al., 2003). Teachers were given lesson plans, student worksheets, instructional materials and technology resources, thus providing maximum scaffolding and minimal flexibility for unit modification.

Despite the extensive support provided to LeTUS teachers, teachers still reported difficulties with implementation related to limited understanding of both associated science content and technology. Since workshop activities were not designed to develop content knowledge, some teachers lacked adequate domain knowledge. Thus, while implementing LeTUS activities— answering students' questions, and facilitating the students' work—teachers lacked the requisite content knowledge needed to effectively model, question, and support students' investigations during the unit (Kubitskey et al., 2003). Similar findings were found in mathematics where Ma (1999) found that American elementary mathematics teachers' lack of content knowledge led them to be more didactic. Further, in cases where teachers attempted to implement learner-centered instruction, they struggled to lead discussions and answer students' questions about the mathematics that was embedded in the tasks.

The CGI project (Carpenter et al., 1996; Fennema et al., 1996) also emphasized knowledge of content and pedagogy. Participating teachers completed mathematical tasks and learned how specific tasks were aligned to stages of children's cognitive development. Rather than focusing on developing teachers' content knowledge, the CGI workshops prepared teachers to attend to their students' work and mathematical thinking. As teachers enacted tasks with their own students they connected workshop constructs and pedagogies related to children's mathematical thinking with their students' experiences. While attempting to implement tasks, teachers were increasingly sensitized to their students' success and began posing more tasks appropriate to student's cognitive level (Fennema et al., 1996). During the CGI project, teachers both observed models of tasks being enacted and worked with mathematical tasks prior to implementing them in their classrooms.

Reflective

Reflection has been identified as critical to teachers' learning activities (Fernandez, 2003; Schon, 1985) and learner-centered professional development. Professional development literature is replete with recommendations that professional development focus on teachers' everyday practice (Ball & Cohen, 1999; Loucks-Horsley et al., 2003), be situated in teachers' work (Putnam & Borko, 2000), and allow teachers to examine specific instances of teaching in their own classroom (Recesso, Hannafin, Deaton, Shepherd, & Rich, in press). However, professional development efforts have been criticized for focusing on activities and resources that have little connection to classroom practice (Guskey, 2000; Little, 1993).

Reflective activities both help teachers to connect professional development activities to their classroom practice and enable researchers to examine teacher practice during and after professional development. In recent years, video and computer-based technologies have been used to facilitate teacher learning (e.g., Marx et al., 1998; Recesso et al., in press; van Es & Sherin, 2002). These technologies allow teachers to watch, examine and critique their own classroom practice, and identify specific instances of effective teaching practices as well as instances where approaches can be refined (Recesso et al., in press).

Sherin and van Es (2005; van Es & Sherin, 2002) brought middle school teachers together monthly to view, discuss, and analyze video examples of their mathematics instruction. Teachers videotaped their teaching, then used a computer-based tool (Video Support Analysis Tool: VSAT) to study their approaches and discuss instances where the students interacted with mathematics content, the teacher, or classmates. Each video was first analyzed in a group, which enabled teachers to share perspectives on the tasks posed and teacher-student interactions. After the discussion, the teacher of the lesson used the VSAT tool to reflect on individual teaching and discuss potential modification in their future instruction. After reflecting, teachers attended more frequently and specifically to students' mathematical thinking and mathematics in the lesson activities. Further, based on follow-up classroom observations, the researchers reported increasingly student-centered pedagogy, as teachers gave students opportunities to communicate their mathematical ideas (Sherin & van Es, 2005). They recommended further examination as to differences in teachers' use of video and the influence of video reflection on their practice (Sherin & van Es, 2005).

While reflection has the potential to impact teacher's practice, the manner in which it is instantiated, the information available, and the timing and frequency appear to influence how (or if) practices are changed. Research is needed to examine the influence of both the activities and evidence (e.g. lesson plans, student work samples, student assessment data, video clips) used to reflect on reflect on practice. Further, as in the case of the video clubs project (Sherin & van Es, 2005; van Es & Sherin, 2002), research is needed to determine how best to scaffold the reflective process to help teachers examine their teaching practice.

Researchers and professional developers have documented evidence to suggest uncertainty in exactly what, and how much, learner-centered activity is actually implemented following professional development (Guskey, 2000; Loucks-Horsley et al., 2003). Some teachers report epistemological conflicts with learner-centered activities, resist implementing these activities, and do not experience the conceptual change requisite for implementation (Franke, Carpenter, Levi, & Fennema, 2001). Others intend to employ learner-centered activities but compromise them by providing pedagogically incompatible procedures (e.g., CTGV, 1997; Peterson, 1990; Wilson, 1990). Finally, teachers may espouse that they are implementing learner-centered activities, but observations of their teaching prove otherwise (Peterson, 1990).

Professional development research is needed to identify characteristics that influence both teacher practices and student learning. Following his synthesis of recommendations for professional development, Guskey (2003) concluded that despite the myriad of research studies and recommendations for professional development programs, considerable uncertainty remains about what actually works. In the following section, I adapt Guskey's (2000) framework to frame needed research on learner-centered professional development programs.

Implications for Research

LCPD research implications are organized according to Guskey's (2000) five levels: participant reaction, participant learning, organization support and change, participant use of new knowledge and skills, and student outcomes.

Participant reactions

In LCPD programs, teachers' reactions are useful in assessing the extent to teacher perceive professional development activities as relevant, effective and useful; they also serve as indicators of the likelihood teachers intend to apply LCPD knowledge and skills in their classroom (Loucks-Horsley et al., 2003). More importantly, teachers are both active participants and co-designers in LCPD; feedback regarding their perceptions can enable design adaptations that increase the likelihood and success of subsequent implementation (Guskey, 2000). In the LeTUS project, for example, teachers reported limited knowledge of content and technology, insufficient time to implement the materials, and a need for additional school-based support after the first year of the project (Fishman et al., 2003; Schneider et al., 2005). Left unaddressed, these concerns presented significant barriers to both the effectiveness and sustainability of the classroom implementation. Based on survey and interview data from participants, the project staff was able to formatively evaluate and modify the activities for Year Two of the project.

While gauging participants' reactions is useful in evaluating perceptions of learner-centered professional development programs, it is insufficient to assess professional development effectiveness or implementation. Participant reactions provide professional developers with a limited scope of their program's impact and can provide misleading information about the success of the program, simply because participants reported enjoying it (Guskey, 2000). Self-report data have been characterized as subjective and often inaccurate (D. Schacter, 1999); participants have been found to overstate their intentions to implement nuanced learner-centered activities more extensively and pervasively than evident in their actual practices (Buck Institute for Education, 2002; Mullens, 1998; Ravitz, 2003). Professional development research needs to extend beyond participants' reactions and self-reported data (Borko, 2004; Georgia House, 2005) to include evidence of learner-centered classroom implementation.

Participant learning

A primary goal for LCPD is to provide teachers with opportunities to develop knowledge and skills to positively impact student learning. Consistent with learner-centered instruction, teachers "own" the focus of their professional development. LCPD can emphasize developing content knowledge, pedagogy, and/or use of instructional resources. Hence, individual teachers focus to a greater or lesser extent on different elements of professional development. In LCPD involving significant content understanding, epistemological beliefs and practices, technology integration, and associated practices, it is important to establish the extent to which critical knowledge and skill has been learned. To this end, research is needed to identify potential gaps between the knowledge and skills deemed fundamental to professional development and knowledge and skill gained by individuals during LCPD.

Recently, for example, researchers have developed tests to measure teacher's content knowledge needed for teaching reading (Phelps & Shilling, 2004) and mathematics (Hill et al., 2005). These tests attempt to examine content knowledge in the context of teaching, and to provide evidence of teachers' knowledge likely to influence the implementation of learner-centered tasks. LCPD professionals and researchers may use similar assessments to better identify teacher's initial needs for professional development activities as well as to assess a program's impact on teacher's knowledge for teaching.

Further, we need to examine teachers' knowledge of pedagogy, technology and other resources associated with learner-centered instruction. LCPD supports teacher's learning of how to integrate those resources into the classroom to support student learning; to do so in a manner consistent with learner-centered epistemology, conceptual change may be required regarding the nature and locus of knowledge (Richardson, 1990) as well as the methods through which teachers engage students (Hawley & Valli, 1999).

Research is needed to examine how LCPD influences both teachers' beliefs and skills related to learner-centered teaching with technology.

In addition, portfolios containing lesson plans and implementation artifacts can include student learning evidence, but they often fail to adequately document how learner-centered principles are enacted in classrooms or their impact on student learning (Guskey, 2000). While examinations of teachers' knowledge are useful, these methods give little detail about how teachers actually enact learner-centered tasks in their classroom.

The effectiveness of learner-centered tasks is substantially influenced by the teacher's role during enactment. Teachers are charged with posing worthwhile tasks, equipping students with appropriate resources and then facilitating learning during the task (McCombs & Whisler, 1997). Teacher's actions during the enactment of learner-centered tasks have been empirically connected to their content knowledge (Kubitskey & Fishman, 2005; Ma, 1999), knowledge for teaching (Stein, Grover & Henningsen, 1996) and knowledge of how to integrate resources such as technology into their classroom (Ertmer, 1999). Therefore, LCPD research must consider how teachers carry the various types of knowledge from LCPD into their classroom.

Organization support and change

In order to become collaborative and be comprehensive, LCPD programs emphasize classroom implementation support—support rarely available or provided in routine professional development initiatives. Attempts to study the impact of LCPD on the school and district resources have proven problematic due to the complex and numerous variables involved. These variables include access to resources, administrative support, school policies, and building-level support. Professional developers (Hawley & Valli, 1999; NPEAT, 2000a) and educational reform researchers (Bay et al., 1999; Fullan, 1991) have underscored the importance of support from leaders at the school building and school district levels. In both the QUASAR (Stein & Brown, 1997) and the LeTUS projects (Fishman et al., 2003), learner-centered task implementation was directly influenced by the relationships among professional developers, researchers, teachers, school administrators and district-level personnel. At one middle school in the QUASAR project, the implementation of learner-centered mathematical tasks did not improve until the teachers received support from their district mathematics coordinator (Stein & Brown, 1997).

Further, professional development research has suggested the presence of conflicting or contradictory goals between and among teachers, professional developers and school-district personnel (Fullan, 1995; Loucks-Horsley et al., 2003). In the QUASAR project, teachers were encouraged in their professional development to use learner-centered approaches to teaching, but their district's emphasis on increasing student achievement on skills-based assessment led them to teach algorithms to support the completion of computational tasks. Teachers recognized competing goals and teaching methods, and did not enact learner-centered tasks until concerns about competing priorities and the need for in-school support were addressed. Further study of the support anticipated, needed, and provided to implement learner-centered activities and tasks is needed to assess both the implications of adopting learner-centered curriculum and pedagogy on school resources as well as its impact on the school, school district and support organizations.

Participant use of new knowledge and skills

Learner-centered professional development aims to support teachers' enactment of learner-centered tasks (NPEAT, 2000a); research is needed to examine the nature of, and extent to which, LCPD knowledge, skills, and practices carry over to implementation in everyday classrooms. In situ data from classroom observations and videos of teacher's classrooms can provide rich evidence and document the extent and the manner in which teachers design and implement the learner-centered tasks emphasized during professional development.

Video technologies allow researchers to capture evidence of teacher's enacted practices. Teachers are influential during learner-centered instruction and must facilitate learning during implementation by modeling processes, asking questions that probe student thinking and providing scaffolds to guide learning (McCombs & Whisler, 1997). Video-based data allow LCPD researchers to document and analyze the enactment of learner-centered tasks. Researchers can identify specific instances in which teachers demonstrate strategies that are likely to influence student learning.

Video can also be used to support LCPD program implementation, such as using classroom observations to formatively evaluate and modify LCPD programs (Borko, 2004). For example, teachers in the ACOT project struggled with the classroom logistics, such as troubleshooting with technology, facilitating a learner-centered, technology-rich task and managing a class in the midst of completing tasks (Sandholtz et al., 1997). As a result of these observations, the ACOT staff developed centers where teachers could observe exemplar teachers as they posed learner-centered tasks to their students. After such observations, teachers indicated greater comfort enacting learner-centered tasks and reported fewer problems posing tasks to their students.

In addition, research is needed to examine the relationships between and among teacher's intended and espoused teaching practices. Previous studies have suggested significant shifts in self-reported attitudes, beliefs and practices (e.g. Garet el al., 2001; Loucks-Horsley et al., 2003; Sandholtz et al., 1997). Despite optimistic indications of intentions to implement, and self-reports of changes in teaching practices following professional development, few researchers have corroborated corresponding changes in classroom practices (Buck Institute, 2002; Ravitz, 2003; Wilson & Berne, 1999). Research is needed to link teacher intentions to enact learner-centered tasks, self-evaluations of classroom enactments, and actual classroom practice. The alignment or disconnect between these three constructs may provide important insights into both how to scaffold teacher learning and support implementation as well as improved ability to identify the presence of LCPD characteristics in classroom practice.

Student learning

LCPD programs must effectively prepare teachers to improve student learning. Hence, LCPD research should examine the impact of the program on student learning outcomes. Historically, few have examined the impact of professional development on student learning outcomes (Guskey, 2005); recently, however, the need to document the influence of professional development on student learning has grown significantly (Borko, 2004; NCLB, 2002). Both educators and policymakers seek evidence confirming or disproving assumptions as to the impact of teacher professional development on student learning (NCLB, 2002; Guskey, 2005). While some researchers have attempted to link professional development to student achievement (e.g. CTGV, 1997; Fennema et al., 1996; Kubitskey et al., 2003; Sandholtz, et al., 1997), such efforts are rare and, unfortunately, often inconclusive.

Due to the significant ongoing investment of time, effort, and resources to support LCPD, and assumptions as to improvements in student reasoning and learning associated with learner-centered instruction, documentation of student impact is especially important (Georgia House, 2005; NCLB, 2002). Recently, researchers have attempted to attribute increases in statewide achievement scores or self-created measures of student learning to teachers' participation in professional development (e.g. Bay et al., 1999; Fennema et al., 1996; Fishman et al., 2003; Fogleman & McNeil, 2005; Knezek & Christensen, 2004). While these methods attempt to link LCPD to student learning, the measures often are not aligned to either LCPD or the learner-centered practices that teachers enacted in their classroom. In instances where evidence suggests that student learning improved, justification for associating such gains to LCPD has proven elusive (Ringstaff et al., 1997; Knezek & Christensen, 2004).

Linking professional development with student learning. In many cases, professional development projects provide only a cursory examination of participants' self-reported feelings and impressions of the professional development (Guskey, 2000; Guskey, 2005). Recent legislative mandates to increase the accountability of professional development programs as well as the rigor of evaluations have contributed to the desire to link professional development to student learning (Georgia House, 2005; NCLB, 2002). Efforts to link LCPD to student learning often attempt to demonstrate a return-on-investment (e.g., time, money and resources expended in proportion to improvements in student learning).

In order to link LCPD's impact on teacher learning and student learning, we need to align associated teacher learning from LCPD and classroom enactments of learner-centered tasks with student performance measures appropriately aligned with, and sensitive to, knowledge, skills, and processes that are associated with learner-centered tasks. However, definitive attributions of impact have rarely been documented in either professional development generally or LCPD in particular. Claims as to the impact of LCPD are largely anecdotal and baseless in the absence of evidence of classroom enactment and appropriately aligned measures of student learning. In situ data from teachers' classrooms may provide insight into how participants enacted the knowledge and skills learned during the professional development (*enacted practices)* as well as the tasks that the teacher had planned (*intended practices)* (Remillard, 2005). These data may strengthen claims of LCPD's influence on the enactment of learner-centered instruction.

Researchers examining student learning outcomes often report student learning on norm-referenced, standardized tests (NCES, 2000, 2004; Wenglinsky, 1998). While improving student achievement on these assessments is valuable, measures of student learning that are aligned with the goals of LCPD and associated classroom practices may provide compelling evidence of the link among teacher learning, classroom enactment and student learning. The CGI and the LeTUS projects both used assessments of student learning that aligned to their professional development. Ultimately, the type and nature of the formative evidence of student learning can become increasingly sophisticated as their predictive properties related to student learning on formal measures are established.

In addition to efforts that link LCPD to student learning, it is also important to examine student learning on measures that are influenced indirectly by learner-centered instruction. For example, researchers in the *Jasper* project examined student learning on both computational and problem solving skills in mathematics (CTGV, 1997). The researcher's goal was to examine how learner-centered instruction influenced student performance on learner-centered tasks as well as basic computational tasks. When compared to non-Jasper classrooms, *Jasper* students scored significantly higher on measures of problem solving and comparable to non-Jasper students on measures of computational skills. Thus, researchers provided evidence that the use of learner-centered tasks improved problem solving skills without adverse effects on computational skills (CTGV, 1997).

Conclusion

Clearly, we need to more closely examine how to best support classroom implementation of learner-centered tasks and the influence of these tasks on student learning. Previous research has identified numerous barriers that teachers confront as the attempt to enact learner-centered tasks in their classroom. Research is needed to identify and refine LCPD components that influence teacher learning, classroom implementation of learner-centered tasks, and the impact of learner-centered tasks on student learning.

Table 2.2: Characteristics of Learner-Centered Professional Development (LCPD) Programs

Characteristic	**Literature on Teacher Learning and Professional Development**	**APA Learner-centered Principles (APA Work Group, 1997)**
Student-focused	Professional development should focus on analyzing the gap between (a) goals and standards for student learning and actual student performance and (b) prepare teachers to bridge that gap (Hawley & Valli, 1999).	The learning of complex subject matter is most effective when learners construct meaning from information and experience (Principle 1). The successful learner, over time and with support, can create meaningful, coherent representations of knowledge (Principle 2).
Teacher-guided	Professional development should involve teachers in selecting the content of professional development programs and, if possible, give teachers choices about learning activities (Hawley & Valli, 2000; NPEAT, 2000a).	Individual's learning is influenced by their motivation (Principle 9). An individual's motivation is influenced by their beliefs and interests (Principle 7), the learner's creativity and curiosity (Principle 8), and their background and experiences (Principles 10, 12 and 13)
Collaborative	Professional development should allow teachers to collaboratively work together (NPEAT, 2000a; Sparks & Hirsch, 2000) and develop the problem solving skills needed to teach effectively (Putnam & Borko, 2000).	Social interactions, interpersonal relations, and communication with others all provide opportunities for learning (Principle 11).
Comprehensive	Professional development should be connected to a comprehensive change process focused on improving student learning (Hawley & Valli, 1999).	The successful learner, over time and with support and instructional guidance, can create meaningful, coherent representations of knowledge (Principle 2).
Content and pedagogically-based	Student learning can be influenced by increasing teachers' content knowledge (Ball, Lubienski, & Mewborn, 2001), pedagogical content knowledge (Marzano, Pickering & Pollock, 2001) and by examining how students learn (Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996).	The learning of complex subject matter is most effective when it is an intentional process of constructing meaning from information and experience (Principle 1). The successful learner, over time and with support and instructional guidance, can create meaningful, coherent representations of knowledge (Principle 2). Individual's learning is influenced by their motivation (Principle 9).
Reflective	Professional development should allow teachers to reflect on evidence of their teaching: (a) student work samples and (b) artifacts from their own teaching (Hawley & Valli, 1999; NPEAT, 2000a).	The learning of complex subject matter is most effective when it is an intentional process of constructing meaning from information and experience (Principle 1). Assessment is an integral part of the learning process (Principle 14).

Table 2.3: Examples of Professional Development Programs that Exhibit Learner-Centered Characteristics

Program	Goal	Characteristics	Description
Cognitively Guided Instruction (CGI) (Carpenter, Fennema, & Franke, 1996; Fennema et al., 1996)	To improve teachers' mathematics instruction in elementary grades by examining students' mathematical thinking.	Student-focused	Teachers examined student work samples while solving mathematical tasks.
		Teacher-guided	Teachers wrote mathematical tasks appropriate for their students. The teachers then returned to workshops to discuss their tasks and refine them for future use.
		Collaborative	Teachers collaborated in workshops to solve tasks, discuss tasks and design tasks to use with their students.
		Comprehensive	Teachers from the same school district participated in the project over a few years.
		Content and pedagogically-based	Teachers learned about types of mathematical tasks, how to match tasks with students' cognitive development, and designed tasks to use with their own students.
		Reflective	Teachers examined student work samples and videotapes of students solving tasks. Teachers reflected on their own students solving the tasks that they wrote.
Center for Learning Technologies in Urban Schools (LeTUS) (Blumenfeld, Fishman, Krajcik, Marx, & Soloway 2000; Fishman, Marx, Best, & Tal, 2003; Schneider, Krajcik, & Blumenfeld, 2005)	To improve students' learning in middle grades science through the use of technology-rich inquiry-based science units.	Student-focused	The units were designed by project staff to teach science standards in a constructivist-based, open-ended manner.
		Teacher-guided	Year two activities addressed the concerns that teachers expressed at the end of year one.
		Collaborative	Teachers supported each other in workshops during activities and in schools while implementing the units.
		Comprehensive	This project was an on-going partnership between the school district and the university to integrate technology-rich, inquiry-based teaching.
		Content and pedagogically-based	Teachers' activities focused on science content they were teaching and constructivist-based pedagogies.
		Reflective	Teachers spent time during the workshops reviewing and reflecting about their implementation of the units.
Apple Classrooms of Tomorrow (ACOT) (Ringstaff, Yokam, & Marsh, 1995; Sandholtz, Ringstaff, & Dwyer, 1997)	To improve student learning in K-12 classrooms through the integration of technology into classrooms.	Student-focused	Teachers designed technology-rich units to address specific content that they taught.
		Teacher-guided	Teachers selected what technologies they were going to integrate, what subjects they were going to focus on and what activities they were going to use with their students.
		Collaborative	Teachers from the same school attended professional development workshops and worked together to plan activities.
		Comprehensive	Teachers participated in this project over a period of years and received resources and professional development to support their teaching.
		Content and pedagogically-based	Teachers learned about best practices for teaching with technology (e.g. collaborative work, inquiry-based projects).
		Reflective	Teachers conducted e-mail and face-to-face reflections with project staff.

Table 2.4: Research findings related to Learner-Centered Professional Development

Program	Goal	Data Sources	Findings
Cognitively Guided Instruction (CGI) (Carpenter, Fennema, & Franke, 1996; Fennema et al., 1996)	To improve teachers' mathematics instruction in elementary grades by examining students' mathematical thinking.	• Classroom observations • Interviews • Student tests (computation and problem solving)	• Teachers were observed exhibiting CGI-based instructional practices. • Teachers reported their beliefs about mathematics learning became more aligned with CGI. • Student achievement increased at different rates on a problem solving test. • Student achievement remained constant on the computation test. • Students who spent two years or more with CGI teachers scored higher on Problem Solving tests. • Student achievement scores on a problem solving test were significantly greater than control classrooms after using CGI-based instructional practices.
Center for Learning Technologies in Urban Schools (LeTUS) (Blumenfeld, Fishman, Krajcik, Marx, & Soloway 2000; Fishman, Marx, Best, & Tal, 2003)	To improve students' learning in middle grades science through the use of technology-rich inquiry-based science units.	• Pre and post-tests • Surveys • Focus-group interviews • Observations of workshops and classrooms	• Teachers reported being more prepared to support students' work with the units. • Teachers were observed using activities from the professional development regularly in their classroom. • Students' post-test scores were slightly higher than the pre-test scores in year one of the project. • Students' post-test scores were significantly higher than the pre-test scores in year two of the project.
Apple Classrooms of Tomorrow (ACOT) (Ringstaff, Yokam, & Marsh, 1995; Sandholtz, Ringstaff, & Dwyer, 1997)	To improve student learning in K-12 classrooms through the integration of technology into classrooms.	• E-mail reflections • Interviews • Classroom observations • Audio-taped lessons	• Teachers reported using the learner-centered activities that were included in the professional development materials. • Teachers reported that students were more motivated to complete activities and learn content that was taught using technology. • Teachers were observed doing more facilitating in their classroom and using less traditional instructional approaches. • Students in ACOT classrooms did not score higher on nation-wide standardized tests.
Video club project (Sherin and van Es, 2005; van Es & Sherin, 2002)	To improve teachers' capacity to notice classroom interactions and attend more to students' thinking	• Interviews • Classroom observations • Observations of workshops	• Teachers made more comments about students' mathematical thinking. • Teachers made more specific comments about students and the mathematics that they were doing. • Teachers' instruction included more opportunities for students to communicate their ideas about mathematics

Chapter III

METHODOLOGY

Typically, professional development researchers report their findings in terms of survey and interview data (Guskey, 2000). While these are necessary to examine participants' perceptions about their learning experience, these data alone are not sufficient to gauge the impact of professional development. In Georgia, the *A Plus Education Reform Act of 2000* (Georgia House of Representatives, 2000) mandates that, "Staff and professional funds shall be used for activities that enhance the skills of certificated personnel and directly relate to student achievement." In order to understand the impact of professional development programs, evidence about teacher's classroom practices must be examined.

This interpretive study examined the extent to and manner in which teachers enact the activities and practices emphasized during learner-centered professional development (LCPD) in their instruction. Further, the study aimed to describe how artifacts of student understanding are shaped by teachers' enactment of instructional practices stressed during professional development. The participants took part in a professional development program designed to prepare them to teach mathematics in a more investigative way, integrate appropriate resources (manipulatives and technology) into their mathematics classroom, and attend more closely to their students' mathematical thinking.

Three research questions guided the study:

1. *To what extent (and how) do teachers enact the practices emphasized in a learner-centered professional development program during their mathematics teaching?* While teachers often report that professional development has helped them information is rarely collected about how teachers infuse these concepts into practice within their classroom (Guskey, 2000, 2005). The study used classroom observations and video-recorded lessons to determine how participants utilize LCPD instruction.
2. *How do teachers' enactments of the practices emphasized during a learner-centered professional development program compare with their espoused and intended practices?* A gap exists between both professional development practices and activities implemented in typical classroom settings, as well as between teacher beliefs about their practices and evidence of *in situ* classroom pedagogy (e.g., Buck Institute, 2002; Peterson, 1990; Ravitz, 2003). While teachers report that they intend to implement the practices emphasized during professional development, there is often little evidence of application within the classroom. This study examined data from classroom observations, video-recorded lessons, and semi-structured interviews to compare teachers' espoused (what they believe they do), intended (what they plan to do), and enacted (what they actually do) practices in their mathematics classroom.
3. *How does evidence of student understanding reflect their teacher's enacted practices?* In order to understand the link between teacher practices and student learning, the following must be examined: the relationships among professional

development programs, teacher enactment of the professional development content, and student learning (Guskey, 2000). To achieve this, I recorded field notes about how students' mathematical understanding was represented during implementations.

Participants and the Research Site

Purposeful selection. I used criterion sampling, a type of purposeful sampling (Patton, 2002) to select two participants for this study. Purposeful sampling enables the researcher to "learn a great deal about issues of central importance to the purpose of the research" (Patton, 2002, p. 46). The criteria for selecting participants included a) participants' self-reports about what they hoped to learn during their professional development and b) participants' self-reports that they intended to frequently enact the professional development's emphasized instructional practices in their classroom. The data sources for selection were teachers' responses on the participant information sheets (Appendix A) and my own observations and field notes during the first four days of workshops (August 2-4 and August 30, 2005).

Participant recruitment. While recruiting participants for this study I encountered many problems. First, only 12 of the expected 24 teachers attended the first three days of workshops. I wanted to select participants who had attended all of the workshops, since they would be more likely to enact the professional development practices before those teachers who missed the first few days. By examining the participant information sheets and observing participants, only three of those twelve teachers showed a sincere interest in regularly enacting the professional development's emphasized instructional practices throughout the year. Shantel, a fifth grade teacher, agreed to participate. The second teacher declined since his classroom was “full of behavior problems.” The third teacher was involved with two other intense professional development projects and spoke with the project staff about being overwhelmed and possibly too busy to participate throughout the whole year. At the request of the professional developers, I did not ask her to participate.

After the fourth day of workshops on August 30th I decided to expand my pool to include the 12 teachers who had missed the first 18 hours of workshops under the condition that they met my original criteria and attended the make-up sessions for the workshops that they missed. However, 7 of the 12 teachers who missed the first three days were first or second-year teachers. I did not consider them, because I suspected that they would spend the year learning the curriculum, rather than being open to incorporate the professional development practices into their teaching.

On September 15, I drove to Shantel’s school. She wanted me to observe her mathematics classroom without a video camera the first time to ensure that I was still interested in studying her and that students were comfortable with having someone observe them during class. During the visit, I expressed to Shantel the need for one to two more teachers for my study. After the observation she introduced me to Keisha, a fourth grade teacher who had missed the first 3 days of workshops, but had attended the 4th day and one of the make-up sessions. I spoke with Keisha about her reaction to the professional development. She reported that she was interested in using more technology and problem solving in her classroom and that she could see herself using the professional development instructional practices frequently. I invited Keisha to participate in the study and she agreed. That same day, Shantel reintroduced me to

Beatrice, a third grade teacher who had attended the first four days of workshops. Beatrice asked me if she could participate as well. Beatrice was not initially chosen since she reported discontent to being “drafted” by her principal to participate in the program. During this conversation, though, Beatrice reported to me that she was interested in enacting some of the instructional practices in her classroom and that she would like to be included in the study.

However, two weeks later Beatrice withdrew from my study after her first enactment. During the lesson, half of her students were seated off camera since they didn’t have permission slips signed. Those students repeatedly got out of their seat and created classroom management issues. After the lesson, Beatrice apologized for her students’ behavior and asked that I not include her, leaving only Keisha and Shantel as participants.

Both participants reported that they were interested in implementing the professional development practices in their classroom frequently. Both teachers had integrated technology into their classroom, but the technology was limited to websites used to develop students’ computational skills. I suspected that Shantel would be interested in implementing tasks immediately, while Keisha, who had missed the first 18 hours of the professional development, would need more time during the professional development prior to implementing tasks. Due to this, I observed Shantel primarily during the fall, and delayed my observations of Keisha until she had spent more time in the professional development project.

Research Site

Both Keisha and Shantel taught at an urban elementary school (grades K-5) that was situated in the downtown area of a city in the southeastern United States. Table 3.2 summarizes demographic and student achievement information for the participants' school. During the 2004-2005 school year, 95% of the school's 365 students qualified for free and reduced lunch. The students were primarily African-American (79%), while the rest were Caucasian (19%), and Hispanic or Asian (2%).

Table 3.1: Demographic Information for the Research Site

Characteristics	
Percent of students on free and reduced lunch	95%
Ethnicity (2004-2005 School Year)	African-American:79% Caucasian: 19%
Percent of students scoring below proficient on 2003-2004 4th Grade CRCT test	60% *****
Percent of students scoring below proficient on 2004-2005 4th Grade CRCT test	38% *****
***** Below average for students in Georgia as well as other schools in their school district	

The school had met Adequately Yearly Progress (AYP) every year. While scores on the mathematics Criterion-Referenced Competency Test (CRCT) were still low, they had made considerable progress between the 2003-2004 and 2004-2005 school years (Georgia Department of Education, 2005). Both participants attributed this progress to various district-wide initiatives that have been led by the district mathematics coordinator.

TIM: A Case of Learner-Centered Professional Development

Technology Integration in Mathematics (TIM) was chosen as the professional development program for this study because it focused on components aligned with the goals of learner-centered professional development (LCPD). Table 3.2 aligns LCPD characteristics with components of TIM.

Table 3.2: Alignment of TIM to Learner-Centered Professional Development (LCPD)

LCPD Characteristic	Description of Characteristic	Components of the TIM Project
Student-focused	Professional development should focus on analyzing the gap between (a) goals and standards for student learning and actual student performance and (b) prepare teachers to bridge that gap.	• Teachers used video and written cases to deepen their understanding of students' mathematical thinking. • Teachers co-planned with project staff and implemented technology-rich mathematical tasks that address the state mathematics curriculum and their students' needs.
Reflective	Professional development should allow teachers to reflect on evidence of their teaching: (a) student work samples and (b) artifacts from their own teaching.	• Teachers used the Video Analysis Tool (VAT) to videotape their own instruction • Teachers watched video of their own teaching and responded to reflection questions posed by the project staff.
Teacher-owned	Professional development should involve teachers in selecting the content of professional development programs and, if possible, give teachers choices about learning activities.	• Teachers planned and implemented mathematical tasks on topics of their choice. These tasks addressed the state mathematics standards as well as their students' needs.
Content and theory-laden	Professional development should provide opportunities to understand the theory underlying the knowledge and skills being learned.	• Teachers worked with video and written cases to deepen their understanding of mathematical concepts as well as their students' mathematical thinking. • Teachers participated as learners in model technology-rich mathematical tasks during workshops. These tasks will also allow teachers to learn mathematics in an investigative manner, which they will be encouraged to use in their own classroom.
Collaborative	Professional development should allow teachers to collaboratively solve problems and develop the problem solving skills needed to teach effectively.	• Teachers participated in professional development with other teachers from their school. • Teachers were encouraged to co-plan and collaborate with other teachers from their building with the integration of technology-rich mathematical tasks. • The project staff worked with teachers throughout the year to provide resources, co-plan with teachers and support teachers' implementation of mathematical tasks that the teachers chose to integrate in their classroom.
Comprehensive	Professional development should be connected to a comprehensive change process focused on improving student learning.	• All of the teachers work in the same school district. • The professional development supported two statewide initiatives: improving student achievement in mathematics at the elementary grades, and preparing teachers to use more task-based activities to teach the new Georgia Performance Standards.

Student-focused

Professional development activities should prepare teachers to bridge gaps between their students' current and desired performance (Hawley & Valli, 2000; Loucks-Horsley & Matsumoto, 1999). Participants analyzed video and text-based cases of mathematics teaching and examined how the teachers in the cases enact key instructional practices. Participants also co-planned with the project staff to use instructional practices emphasized in the professional development to teach content that students typically have difficulty learning.

Teacher-owned

Teacher motivation to engage in professional development increases when they participate actively in their own learning (Loucks-Horsley et al., 2003). During the workshops, participants explored mathematics-related technologies and pedagogies, and solved mathematical tasks. They also spent time discussing how to incorporate what they were learning into their own mathematics teaching. Also during one workshop, teachers had the opportunity to use the computer to identify technologies that they could use to support their mathematics teaching.

Reflective

Professional developers have contended that teacher learning is most effective when activities are embedded in teacher's daily practice (Ball & Cohen, 1999), situated in their work (Putnam & Borko, 2000), and allow opportunities for reflection (Schon, 1983). During the year, participants co-planned three mathematics lessons in which they planned to use instructional practices that were aligned with the goals of the professional development. The first two lessons were co-planned with the project staff, while the third lesson was designed independently. The professional developers originally intended to have teachers record all three lessons and use the Video Analysis Tool (VAT; http://vat.uga.edu) to reflect on their teaching. However, the school district had blocked streaming video from entering the schools, leaving teachers with no in-school access to videos. The professional developers then modified this requirement, requiring that only the third lesson be recorded.

Content and Theory-laden

In order for teachers to enact content-specific practices, professional development must focus on specific content, learning theories, and pedagogies (Desimone et al., 2002; Garet et al., 2001). This project aimed to improve participants' comfort with mathematics-related technologies, their own mathematical knowledge for teaching, and prepare them to employ learner-centered approaches to teaching mathematics. The professional development focused on geometry, measurement, multiplication and division. During the workshops, the participants analyzed cases of mathematics instruction from the Developing Mathematical Ideas (DMI) curricula (Schifter, Bastable, & Russell, 2002), completed learner-centered mathematical tasks, and worked with mathematics-appropriate technologies.

Collaborative and Comprehensive

Research on professional development has illuminated the importance of encouraging teachers to collaborate with colleagues and form learning communities (Fishman et al. , 2003; Silver & Stein, 1996; Smith & Brown, 1997). Teachers attended workshops with colleagues from their school. They collaborated with each other to analyze the DMI cases, complete learner-centered tasks, and explore related technologies.

During the year, the teachers co-planned lessons with the professional developers. Teachers would e-mail ideas for tasks to the professional developers, who would provide feedback and offer suggestions for improving the tasks. In January, the professional developers formalized the co-planning by providing teachers with a lesson protocol that they needed to use while co-planning a lesson.

Studies on educational reform and professional development indicate that teachers are more likely to adopt new instructional approaches if the reform is part of a school, district, or statewide comprehensive effort (Fullan, 1991; Richardson, 1996). The professional development supported statewide initiatives to improve student learning in mathematics by incorporating learner-centered tasks that embodied the process skills included in the new Georgia Performance Standards (GADOE, 2005). This project also aligned with other initiatives and goals that have been implemented by the school district's mathematics coordinator.

Instruments

Video Analysis Tool (VAT)

The Video Analysis Tool (VAT; http://vat.uga.edu) provides opportunities to observe, capture, and analyze video of teacher's enacted practice (Recesso et al., in press). Figure 3.1 shows screen captures of the VAT. The VAT uses three levels of detail for examination purposes: lenses, filters, and gradients. The lenses, filters, and gradients that were used in the study, TIM-Teacher, are shown in Appendix B. These filters were identified as the six instructional practices emphasized during the professional development.

Figure 3.1: Screen capture of the Video Analysis Tool (VAT).

A lens is used to isolate activities for closer examination, such as national mathematics teaching standards (NCTM, 2000); in this study, the set of professional development practices is the lens through which teacher practices were examined. Each lens consists of filters that enable close examination of associated practices. Consistent with recommendations made by mathematics educators (e.g., Schoenfeld, 1992; Fennema et al., 1996, NCTM, 2000), in the study the filters in VAT are the 6 instructional practices emphasized during the professional development. Each filter comprises gradients, akin to rubrics, that qualitatively differentiate the extent to which professional development pedagogies are observed. Using the VAT, a rater can identify specific instances where particular practices occur, annotate and otherwise “mark up” the practice(s), refine the units of practice observed into fine-grained units using filters, and analyze the units further using defined criteria in the form of gradients. The gradients for the TIM-Teacher lens were created after examining previous research that used similar methods to examine teachers' *in situ* mathematics teaching practices (Fennema et al., 1996; Hufferd-Ackles, Fuson, & Sherin, 2004; Schifter & Fosnot, 1993). The TIM-Teacher lens was revised in September 2005, based on feedback from the researcher's committee and in October 2005 after observing a few implementations in participants' classrooms.

The VAT has been used previously across a range of pre-service and in-service settings. The researcher, and members of the researcher's dissertation committee, who are knowledgeable about effective mathematics teaching practices, refined the gradients prior to the beginning of the study. Further, the lens was modified based on observations made during the first two observations.

Interview Protocols

Baseline interview protocol. This protocol (Appendix C) was used to obtain data about participants' espoused and intended practices in mathematics. These questions were adapted from interview protocols used previously in mathematics professional development programs.

Post-observation interview protocol. This protocol (Appendix D) provided information about participants' intended and espoused practices regarding observed lessons. Using it, I asked teachers to share their intended actions during the lesson as well as successes and challenges encountered while teaching. This instrument provided information about the extent to which teachers report enacting the practices emphasized in the professional development in their teaching.

End-of-study interview protocol. The end-of-study protocol (Appendix E) was employed to document participants' reports about their espoused practices as well as their perception of how their instructional practices were influenced by the professional development. It also allowed them to report successes or barriers they experienced while putting these workshop-stressed pedagogies into daily mathematics instruction. This instrument was pilot tested with a participant from a previous professional development project.

Project staff interview. This protocol (Appendix F) was used to learn the professional developers' perspectives about the project goals and the emphasized instructional practices. The interview was conducted after the first three days of the summer workshops. This instrument was pilot tested with a graduate student who had worked on previous mathematics professional development projects.

Implementation of the Study

Table 3.3 details the activities that took place during the study. Implementation occurred both during the workshops and during participants' mathematics teaching.[2]

Activities during Workshops

Throughout the workshops, participants engaged in written and video-based cases of elementary teachers' mathematics instruction. They discussed the cases, specific instructional practices used, and how teachers attended to their students' mathematical thinking. Participants also explored mathematics-related technologies such as calculators, spreadsheets, internet-based tools, and software programs. Further, participants worked on mathematical tasks and discussed how these tasks could be adapted for use with their own students.

Activities during Participants' Mathematics Teaching

Co-planned lessons. The professional developers instructed teachers to co-plan

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[2] Table 3.3 appears at the end of this section on pages 63 and 64.

their first two lessons via e-mail with the project staff. Initially, the teachers were told to e-mail ideas for tasks to the professional developer, who provided feedback and suggestions prior to implementation. The teachers were also were supposed to video record the implementation and mail it to the professional developer, who would put the video into the VAT so the teachers could review and reflect on their teaching.

Independently planned lesson. Teachers' third implementation was a lesson that they planned independently and included tasks and instructional practices that were consistent with the professional development goals. Similar to the co-planned lessons, teachers were instructed to record the lesson, mail it to the professional developer and then complete a reflection using the VAT.

Mathematics teaching activities for this study's participants. Shantel and Keisha were both purposefully selected because they reported an interest in enacting the professional development practices frequently during the school year. Therefore, it was expected that both Shantel and Keisha would do more than three implementations. Since only two of their implementations were co-planned, the participants enacted lessons that were independently planned or lessons that were taken directly from the professional development workshops (direct adoption lessons).

Directly adopted implementations had been modeled by the professional developers either during workshops or model teaching when project staff taught lessons in participants' classrooms. The directly adopted lessons were the most scaffolded of participants' implementations, since they had observed the professional developers implement the tasks and learner-centered pedagogies that were associated with the lesson.

Data Collection Activities

The data collection for this study consisted of observations of professional development workshops, examination of the participants' mathematics teaching, interviews with participants, and the assessment of classroom artifacts.

Observations of professional development workshops. I attended all of the workshops held between August, 2005 and March, 2006. This accounted for approximately the first 36 of the 48 hours of workshops. During these, I served as an onlooker (Patton, 2002) taking field notes. I focused on the project staff's discussions and the instructional practices that they explicitly discussed during the workshops. I also observed participants' activities and discussions as they engaged in the workshop's activities (e.g. cases, model lessons, lesson planning), documenting field notes and memos immediately following each workshop (Bogden & Biklen, 2003).

Observations of classroom instruction. I observed participants' mathematics classrooms on days when they intended to use instructional practices that they felt were aligned with the professional development. During each lesson I used a camera and a wireless microphone to record the implementation. I also took field notes and attended to students' actions. I typed the field notes and wrote memos for the notes in a word processor soon after the observations.

Evidence of student understanding. During implementations I videotaped and recorded field notes on the students' activities. I focused on how students represented their understanding of the mathematics content that was embedded in each task. These representations included students' arrangement of manipulatives, as well as tables, drawings, computations and answers that students generated. During observation I frequently moved the camera to record representations and roved around the classroom to look at students' work.

Table 3.3: Timeline for Research Procedures

Date	Event(s)	Research Activities	Data Collected
Aug. 2-4	Workshop	Participants attend workshops Teachers complete TIM surveys Researcher meets participants	Field notes Participant information forms
Aug. 23	Mathematics Teaching	Researcher conducts project staff interview	Audio-taped interview
Aug. 29	Make-up workshop	Keisha attends make-up workshop	
Aug. 30	Workshops	Participants attend workshop	Field notes
Sept. 15	Baseline Interview Participant Recruitment	Researcher conducts baseline interview with Shantel Researcher recruits Keisha and Beatrice	Audio-taped interviews
Sept. 29	Mathematics Teaching, Baseline Interview	Shantel completes 1st implementation Researcher conducts post-observation interview with Shantel and baseline interview with Keisha	Video of lesson Field notes Audio-taped interviews
Sept. 30	Mathematics Teaching	Shantel completes 2nd implementation Researcher conducts post-observation interview Researcher conducts baseline interview with Beatrice	Video of lesson Field notes Audio-taped interviews
Oct. 5	Mathematics Teaching	Keisha completes 1st implementation Researcher conducts post-observation interview	Video of lesson Field notes Audio-taped interviews
Oct. 12	Mathematics Teaching	Keisha completes 2nd implementation Beatrice completes 1st implementation Beatrice withdraws from the study Researcher conducts post-observation interviews	Video of lesson Field notes Audio-taped interviews
Oct. 28	Mathematics Teaching	Shantel completes 3rd and 4th implementations Researcher conducts post-observation interviews	Video of lesson Field notes Audio-taped interviews
Nov. 4	Workshops	Participants attend workshop	Field notes
Nov. 9	Mathematics Teaching	Shantel completes 5th and 6th implementations Researcher conducts post-observation interviews	Video of lesson Field notes Audio-taped interviews
Nov. 18	Mathematics Teaching	Shantel completes 7th and 8th implementations Keisha completes 3rd implementation Researcher conducts post-observation interviews	Video of lesson Field notes Audio-taped interviews
Dec. 14	Mathematics Teaching	Shantel completes 9th implementation Researcher conducts post-observation interviews	Video of lesson Field notes Audio-taped interviews
Dec. 19	Mathematics Teaching	Keisha completes 4th implementation Researcher conducts post-observation	Video of lesson Field notes

		interviews	Audio-taped interviews
Jan. 4	Workshop	Keisha attends workshop Post-workshop interview	Field notes
Jan. 19	Mathematics Teaching	Shantel completes 10th and 11th implementations Keisha completes 5th implementation Researcher conducts post-observation interviews	Video of lesson Field notes Audio-taped interviews
Feb. 16	Mathematics Teaching	Shantel completes 12th implementation Keisha completes 6th implementation Researcher conducts post-observation interviews	Video of lesson Field notes Audio-taped interviews
Feb. 20	Workshop	Participants attend workshop	Field notes
Feb. 21	Workshop	Keisha attends workshop	Field notes
Mar. 16	Mathematics Teaching	Keisha completes 7th implementation Researcher conducts post-observation interviews	Video of lesson Field notes
Mar. 17	Mathematics Teaching	Shantel completes 13th and 14th implementations Researcher conducts post-observation interviews	Video of lesson Field notes
Mar. 22	Collect end-of-study data	Shantel completes 15th implementations Researcher conducts end-of-study interviews	Video of lesson Field notes Audio-taped interviews

Research Questions, Procedures and Data Sources

Table 3.4 shows the alignment among the research questions, techniques, data sources, and instruments.[3] Data obtained from multiple sources (field notes and videotapes from participants' classrooms, and interview transcripts, were analyzed to examine each of the research questions. The analysis process for each question is described in this section.

Measures of Practice

This study examined participants' enacted, espoused, and intended practices in their mathematics teaching. This section describes how data for each measure of practice were collected and analyzed

[3] Table 3.4 is displayed at the end of this section on page 70.

Enacted Practices. During the study, enacted practices were observable practices that participants carried out in their teaching. Observations of participants' enactment (videos and classroom observations) were the primary data sources for determining their enacted practices. I used the TIM-Teacher lens in the VAT to code videos of participants' teaching. I watched each video after it was recorded to review the goals of the lesson and the instructional practices that they enacted. Then, I used the VAT to mark-up each video. For each video, I created sub-clips any time that I either observed one of the six instructional practices (Appendix B). These instructional practices include algorithms, tasks, student communication, mathematical representations, technology, and questions) or observed a time in which an opportunity for an instructional practice occurred. This happened for two instructional practices, *questions* and *student communication*, where there were opportunities for questions or student communication that did not occur. For each clip, there was evidence of more than one instructional practice (e.g., a teacher questions a student and provides the student with the opportunity to share their thinking while the student is generating a representation of a mathematical concept). In these instances, I marked the same clip for numerous instructional practices.

Once each video was divided into clips and marked, the codes were then entered into a Microsoft Excel spreadsheet (Appendix G). Each clip was in its own row, which included the participant, the date of the implementation, the start time and end time of each clip, each instructional practice (filter) and comments about the clip. The data were then analyzed in the spreadsheet.

For the filters *questions and student communication,* I counted all of the opportunities for these and used Microsoft Excel to calculate a percentage for each gradient within that filter (Appendix H). For the remaining filters I tallied the frequency that each gradient occurred. After tallying and determining percentages, I then examined the comments and memos to identify clips that best demonstrated the specific gradients for the filters that were prevalent during the enactments. The field notes were used to corroborate or refute the findings from the analysis of video.

Espoused and intended practices. Espoused practices included pedagogies that participants reported that they enacted in their teaching. Intended practices included pedagogies that were consistent with the professional development goals that participants planned to use in their teaching. I used data from the various interviews (i.e., baseline, post-observation, and end-of-study) as the main data sources for participants' espoused and intended practices. These interviews were audio-recorded and transcribed verbatim into Microsoft Word. Using the comment feature in Microsoft Word, I identified interview excerpts that were related to teacher's espoused and intended practices and created codes using an open-coding scheme. I copied the transcripts into a Microsoft Excel spreadsheet (Appendix I). During coding I attended to the specific instructional practices in the TIM-Teacher lens, but did not limit my coding to those practices. Appendix J lists all of the top-level codes used to analyze interview data. In the spreadsheet each interview excerpt was in its own row that contained the participant's name, the date of the interview, the interview excerpt, the line numbers of the excerpt, the initial code, and a memo about the excerpt. During analysis I created subcodes within the top-level codes for the excerpts and memoed further about the interview excerpts. Next, I used the codes and excerpts to generate data-based assertions about the participants' intended and espoused practices that related to the filters (instructional practices) in the

TIM-Teacher lens. Secondary sources (field notes from classroom observations) were used to triangulate these assertions.

Analysis of research questions

Question 1: To what extent (and how) do teachers enact the practices emphasized in a learner-centered professional development program in their mathematics teaching? Participant's enacted practices were examined based on the methods described above. Videos of teacher's enactment were the primary data source, while field notes provided data to confirm or refute the findings from the video analysis. Each implementation was analyzed separately at first. Then, implementations were grouped and analyzed according to the origin of the enacted tasks (direct adoption, co-planned, and independently planned).

Question 2: How do participants' enactments of the practices emphasized in a learner-centered professional development program compare with their espoused and intended practices? Data regarding each participant's enacted, espoused, and intended practices were coded, entered into a Microsoft Excel spreadsheet (Appendix K) and analyzed separately for each implementation. Participant's three measures of practice were then examined according to the origin of the enacted tasks (direct adoption, co-planned, and independently planned) to look for common themes and discrepancies within each lesson.

Question 3: How does evidence of student understanding reflect their teacher's enacted practices? Field notes from the implementations and video data about participants' enacted practices were used as the main data sources for this question. The data for each implementation were entered into a Microsoft Excel spreadsheet (Appendix L).

Analyzing evidence by task and task type. During the analyses, evidence was found that within each enactment, teacher-participants posed numerous tasks. A *task*, in this study, referred to any activity with a mathematical goal. During the implementations, participants enacted many tasks of the same type, referred to as a *task type*. For example, the division problem 43 divided by 6 is a task. If a student completes a worksheet with 15 tasks (2-digit number divided by a 1-digit divisor), there would be 15 tasks, but only one task type.

During the data analysis for question three, when the mathematical representations, student communication, and students' representations of mathematical work were similar, tasks enacted during the same implementation were counted as one task type. However, on multiple instances during the study Shantel posed similar tasks to her different classes, the task types were counted for each implementation since they were enacted with two different classes and the associated mathematical representations, communication, and representations of student mathematical work varied.

Validity and Reliability

Internal Validity

Internal validity is used to ensure that the findings from a research study are congruent with reality (Merriam, 2002). In order to ensure the internal validity of the study I used various strategies. These included various forms of triangulation: a) the triangulation of data sources by corroborating my findings using multiple data sources, and b) the triangulation of methodologies by collecting data using observations, videos and interviews, and c) researcher triangulation by using additional raters to code videos of classroom implementations. Further, the internal validity was increased by collecting data across multiple points in time (Merriam, 2002).

This study included data from multiple sources, such as videos of implementation, field notes from classroom observations, participant interviews, and project staff interviews. The data also included both observation-based data (i.e., videos and field notes), as well as self-reported data (i.e., interviews).

Reliability

In order to ensure reliability and accurate representation of the data I employed the previously described process of coding the data, organizing the data, generating sub-codes, making assertions and testing the assertions by reexamining the data (Coffey & Atkinson, 1996; Patton, 2002). Further, I described my biases prior to the study (see the Researcher's Subjectivity Statement in this chapter) (LeCompte & Preissle, 1993) and corroborated data from multiple sources (Coffey & Atkinson, 1996). During the presentation of findings, I used descriptive data from multiple data sources that support findings about multiple participants (Merriam, 2002).

No data in the videos or interviews suggested a fish bowl effect. According to Merriam (2002), while the presence of a researcher may have influenced participants' behaviors, multiple observations over a sustained amount of time adds to the reliability of the findings. By conducting observations for over sixteen hours in Shantel's classroom and eight hours in Keisha's classroom, I am confident that my presence did not influence participants' behaviors.

Table 3.4: Research questions, data sources and analysis

Research Questions	Instruments	Main Data Sources	Complementary Data Sources	Analysis
1. To what extent and how do teachers enact the practices emphasized in a learner-centered professional development in their mathematics teaching?	• Lens of Enacted Practices • Teacher interview protocols • Project staff interview protocols	• Field notes from observations • Videos of classroom teaching	• Interviews with participants • Interviews with project staff • Lesson plans	• Code main data sources using Lens of Enacted Practices • Identify themes in main data for each participant • Corroborate themes with interview data and lesson plans • Analyze data across participants
2. How do participants' enactments of the practices stressed in a learner-centered professional development program compare with their espoused and intended practices?	• Lens of Enacted Practices • Teacher interview protocols • Project staff interview protocols	• Field notes from observations • Videos of classroom teaching • Interviews with participants • Interviews with project staff	• Lesson Plans	• Code field notes and video data using Lens of Enacted Practices • Code interview data using Lens of Enacted Practices as a framework • Identify themes in each data source • Identify themes for each participant • Analyze data across participants
3. How does evidence of student learning reflect teachers' enacted practices?	• Lens of Enacted Practices • Teacher interview protocols • Project staff interview protocols	• Field notes from observations • Videos of classroom teaching • Student work samples	• Interviews with participants • Interviews with project staff	• Code main data sources using Lens of Enacted Practices • Analyze student work samples and enacted practices for each participant • Identify themes for each participant • Analyze data across participants

Interactions between the Researcher and the Participants

During the research study I developed a relationship that was both collegial and professional with the participants. While I never formally led a professional development workshop prior to or during the time that I was collecting data, participants may have associated me with the TIM project. The participants knew that I worked in the same office with the professional developers and shared rides with them to the workshops throughout the year. During the year when the VAT was not working in the school, I helped the participants as well as other teachers in their school try to watch their videos. I was concerned throughout the study about participants viewing me as a participant observer rather than a non-participant observer.

As a result of this concern, I explicitly took precaution in numerous ways. First, I observed their teaching only when participants reported that they intended to use instructional practices that they felt were aligned with the professional development goals. Thus, every observation occurred when participants thought that they were enacting instructional practices that were covered in the workshops. These purposeful observations made participants' perception of my role germane since participants' perception of the emphasized instructional practices came from the workshops and the professional development staff leading the workshops.

During classroom observations I was also careful about maintaining my role as an onlooker. After the participants finished teaching they asked for feedback about their teaching every time. In each instance, we conducted the post-observation interview the same day of the implementation, so I could capture the participants' voice and their report about the lesson soon after the lesson was completed. When the participants asked me for feedback I would respond with general remarks, such as “I thought it was fine” or “I need to go back and watch the video.” While not providing feedback was difficult and ethically perplexing, this approach ensured that I was minimizing my intervention on my participants’ classroom practices.

Researcher’s Subjectivity Statement

My previous experiences as an elementary school teacher, as a participant in professional development programs, and as a professional developer have influenced the way that I view effective professional development programs and the process of supporting teacher learning. While my study’s methodology attempts to limit the bias of my subjectivity, this statement provides background on my professional experiences that may influence my work as a researcher.

I was an elementary school teacher for three years and a participant of a number of professional development initiatives. While I enjoyed the professional development programs, I was aware that I was not benefiting much from them. For the most part, these programs spent hours covering content and activities that had no or little relevance to my teaching practice. That was quite frustrating.

Luckily, my experiences with professional development programs shifted during my second year of teaching. My principal selected me to participate in a Preparing Tomorrow’s Teachers to Teach with Technology (PT3) grant that prepared teachers to integrate technology into our classroom. The PT3 project was very flexible; the professional developer introduced a piece of technology and allowed us to choose whether we spent the workshops becoming familiar with technology, discussing how the technology could be effectively integrated into our classes, or planning lessons that used the technology. I left the workshops excited about my experience. Also, I had a tangible way that I could incorporate my new knowledge into my classroom. This experience opened my eyes to the potentially powerful effect that professional development can have on teachers.

Based on prior research that I have read and studies that I have conducted, teachers are more likely to enjoy professional development programs that allow them to take some ownership of their learning. While completely individualized programs are difficult to design and implement, teachers' opportunities for learning should be individualized enough so that teachers feel that they are learning things that are relevant to their teaching. I believe that teachers need to be able to leave professional development with an idea about what how their experience will influence their teaching and their students' learning.

Based on my experiences, I began the research expecting that my participants would benefit from and enjoy their participation in the TIM project. I expected that the participants would be excited to apply some of their new knowledge into their classroom, especially tasks that involve technology. However, I expected that participants might have difficulty with the barriers that teachers typically face, e.g., access to technology that works, initial problems when implementing learner-centered tasks for the first time, using manipulatives and technology to support student learning, and learning how to design learner-centered tasks. I also am aware that teachers require a lot of time, in professional development workshops learning about new practices and resources, as well as in their classrooms trying new approaches and making sense of their new knowledge and how it can enhance their students' learning experiences.

Due to these factors, I was cautiously optimistic about how teachers' enactments will align with the professional development practices. I believed that teachers would benefit from the TIM program. This was especially the case, since I worked with teachers who reported both interest in the professional development and willingness to enact TIM-related instructional practices throughout the school year. However, since both participants had just begun the professional development project, I was unsure on whether the teacher-participants would enact any TIM-related practices and how their enactments would reflect their learning during the short time of the study.