

EXPLORING THE GENDER GAP IN TANZANIAN SECONDARY SCHOOL  
MATHEMATICS CLASSROOMS

BY

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DISSERTATION

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## **Abstract**

This dissertation is a multiple case study, which follows from my early research study in which I established that there is a mathematics gender gap in Tanzanian secondary schools favoring males (Zilimu, 2009). The purpose of this case study was to explore the teachers' perceptions of their teaching practices in classroom contexts and how their perceptions might perpetuate gender gaps. Although many factors inside and outside of school influence students' level of achievement, the quality of teaching is important for improving students' learning (Hammouri, 2004). Because formative assessment (FA) practices and problem solving approach (PSA) have been shown to improve the performance of lower achievers, the integration of FA and PSA framework guided the data collection methods in this dissertation study. I sought to answer the following two research questions. First, how do Tanzanian secondary school mathematics teachers' understandings of their own teaching reflect a problem solving approach (PSA) and formative assessment (FA) in the context of their instructional practices? Second, how might their teaching practices, the perceptions of their teaching practices, and their classroom contexts perpetuate gender gaps in mathematics achievement?

Three mathematics teachers, each from a different secondary school in the northwestern region of Tanzania participated in this study. In accordance with the characteristics of qualitative research, the evidence for this case study came from multiple data sources a strategy that also enhances data credibility (Merriam, 1997; Patton, 2002; Stake, 1995; Yin, 2009). The data sources for this case study were semi-structured interviews and classroom observations. Interviews with the teachers revealed that the government, school administrators and the teachers were aware of the existence

of gender gap in mathematics and there were efforts to help all students learn mathematics. The results of this dissertation study suggest that more efforts are needed to improve learning environments, such as reducing the number of students per class and improving instructional practices. Recommendations for further studies include students' (especially girls') understanding of gender gaps. Further research is recommended on whether the students acknowledge the existence of gender achievement gaps in mathematics.

*Keywords:* Formative assessment, problem solving, classroom discussions, gender achievement gap, mathematics achievement, secondary school mathematics learning, Tanzanian secondary school classrooms

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## Chapter I

### **Introduction**

The findings from the Third International Mathematics and Science Study (TIMSS) show some significant worldwide gender differences in mathematics achievement in the 8th grade favoring males (Fierros, 1999, April). However, the results of the Trends in Mathematics and Science Study (TIMSS) of 2007 show that at the 8th grade, on average across the participating countries, girls had higher average achievement than boys (Mullis, et al., 2008). Mullis and colleagues (2008) report “girls had higher achievement than boys in 16 of the participating countries . . . Boys had higher achievement than girls in 8 countries . . .” (p. 57). TIMSS-2007 results show that in some countries gender equity in mathematics is still far from a reality. TIMSS findings also show that in the countries where the gender difference in mathematics achievement favoring boys still exists, it becomes more compelling in the students’ last academic year of secondary school (Mullis, et al., 1998).

O’Connor-Petruso and colleagues (2004) have shown that gender differences in mathematics achievement become apparent at the secondary school level when female students begin to exhibit less confidence in their mathematics ability and perform lower than males on problem solving and higher level mathematics tasks. Fierros (1999, April) clarifies that the differences favoring males at this level of study are particularly in “mathematics literacy (i.e., application of mathematics to everyday problems) and even greater . . . in advanced mathematics” (p. 1). Research on gender gap (Hyde & Mertz, 2009; McGraw & Lubienski, 2007) reveals that in some countries such as the United States, gender difference in performance has lost researchers’ attention because it is very

small. Unlike the United States and other countries, the difference between girls' and boys' performance in Tanzania is quite large in almost all subjects. Kaino (2009, September) reports that, "using a national sample of secondary school leavers in Tanzania, Amuge (1987) found that boys outperformed girls in secondary schools in almost every subject except commerce" (p. 4). The difference is even greater in mathematics and science subjects (Masanja, 2004).

Numerous studies have been done on boys outperforming girls in Tanzanian secondary schools (Amuge, 1987; Masanja, 2004; Sutherland-Addy, 2008). However, none of the studies about the gender gap have established the relationship between the teachers' instructional practices and the achievement gaps in mathematics. Although many factors inside and outside of school influence students' level of achievement, the quality of teaching is important for improving students' learning (Hammouri, 2004). According to Butty (2001), instructional practices affect mathematics achievement as well as attitude toward mathematics. Therefore, in this study I seek to explore the relationship between the gender gap and the Tanzanian teachers' instructional practices. Problem solving approach (PSA) and formative assessment (FA) have been shown to improve the performance of lower achievers. In the Tanzanian context, girls are low achievers in mathematics. In this dissertation study I took into consideration that most research done on the effects of PSA and FA practices is from the U.S. and other countries where there is not a huge gender gap favoring males. However, I assume that if PSA and FA practices are done well (by using real world problems), these practices might help improve the girls' achievement in Tanzanian secondary schools. Mathematics classrooms that investigate real world problems and value a variety of solutions allow female

students' voices to be heard (Forgasz, et al., 2010). PSA and FA frameworks inform this exploratory case study. The integration of frameworks of PSA and FA will guide classroom observations and semi-structured interviews in this dissertation study. This point will be expanded later in Chapters II of this dissertation study.

In this dissertation study I seek to answer the following two questions. First, how do Tanzanian secondary school mathematics teachers' understandings of their own teaching reflect PSA and FA in the context of their instructional practices? Second, how might their teaching practices, the perceptions of their teaching practices, and their classroom contexts perpetuate gender gaps in mathematics achievement?

### **Statement of the Problem**

In my early research project (Zilimu, 2009) I established that there is a mathematics achievement gender gap in secondary schools in Tanzania. The early research results confirmed what other researchers had established (Amuge, 1987; Masanja, 2004; Sutherland-Addy, 2008). In the early research study I observed three teachers from three secondary schools. I analyzed the teacher-students' statements or questions and the interactions between the teachers and students. I also analyzed the mathematics scores from the 2008 form four national examinations. Every year in October, the National Examination Council of Tanzania (NECTA) conducts a national examination to all seniors in secondary schools. The results are usually available on the NECTA website. The results of the analysis of the mathematics scores indicated that the difference between the boys' and the girls' scores in the national examinations, was statistically significant. However, the quantitative data indicated that just a small amount of the variance of the national examination results ( $R\text{-square} = 3.8\%$ ) is explained by (or

predicted from) the categorical independent variable (gender). The qualitative data indicated that the mathematics discourse practices (social interactions between teachers and students in classrooms) favored boys. The qualitative and quantitative results in my early research study show that there might be a relationship between the teachers' instructional practices and the achievement gap. I understand that there are factors other than teachers' instructional practices that might be associated with the existence of the gender gap. Research findings show that students' performances in mathematics are due to factors such as home environment (Fullarton, 2004; Howie, 2002; Weiss & Krappmann, 1993), attitude towards mathematics (Hammouri, 2004; Kiamanesh, 2004), and socioeconomic status of the family (Lubienski, 2000; Marjoribanks, 2002). However, the questions remain: What is the nature of the gender gap in Tanzanian secondary schools? Does the teachers' knowledge about PSA and FA affect the quality of teaching? Do teachers acknowledge the effect of gender bias in their teaching practices?

Supportive teachers play a significant role in students' engagement in the classroom. House (2005) notes that students who know their teacher cares about them can get better scores. However, UNICEF (Unicef, 2012) reports that practices such as socialization of gender and gender bias either at the school level or at the classroom level contribute to the existence of the gender achievement gap. Socialization of gender within schools assures that girls are made aware that they are unequal to boys. Gender bias in education occurs when educators or teachers make assumptions regarding behaviors, abilities or preferences of students based on their gender. For instance, every time students are seated or lined up by gender, teachers are affirming that girls and boys should be treated differently. When assertive behavior is promoted among boys and

passive behavior is encouraged among girls, the girls lose self-confidence in learning difficult subjects such as mathematics and science (O'Connor-Petruso, Schiering, Hayes, & Serrano, 2004). O'Connor-Petruso and colleagues (2004) note that in a society where preference toward the boys over the girls is dominant, the girls receive less attention from teachers and the attention that girls do receive is often more negative than attention received by boys.

Gender biased socialization in school makes girls think that mathematics and science are not for them. Social cultural beliefs and practices, such as regarding girls as academically weak students, do not only affect the girls' attitude towards learning but also the way teachers treat girls in classrooms, especially mathematics and science classrooms. Differences in mathematics achievement are the product of social and cultural factors (Fullan, 2001), reasonable expectations (House, 2005), and confidence in mathematics (Wilhite, 1990). TIMSS-2007 results show that there is a positive association between self-confidence in learning mathematics and mathematics achievement (Mullis, et al., 2008). However, for the purpose of this dissertation study, I will focus on the relationship between gender gap in mathematics achievement and the integration of FA into a PSA (teachers' teaching practices). Instructional practices affect mathematics achievement as well as students' attitudes toward mathematics (Akinsola & Olowojaiye, 2008; Butty, 2001). House (2005) notes that a supportive classroom and suitable teaching motivate students to become better mathematics learners.

### **Context and Background of the Problem**

According to the Ministry of Education in Tanzania, the provision of education is a basic human right, and the government's goal is quality education for all Tanzanians

(Tanzania National website, 2001). However, there are still great discrepancies between girls' and boys' performance in school mathematics (Amuge, 1987). It is documented in the *Principles and Standards for School Mathematics* (NCTM, 2000) that “in this changing world, those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures. Mathematical competence opens doors to productive futures. A lack of mathematical competence keeps those doors closed” (p. 5). There is a need to study the nature of the gender gap in mathematics performance in Tanzanian schools in order to keep open the doors for all students, boys and girls. The policy makers and the Ministry of Education in Tanzania might use the results to identify factors that influence mathematics performance in order to reduce gender inequality in mathematics achievement.

#### **Education system in Tanzania.**

The structure of the formal education and training system in Tanzania is based on the 2-7-4-2 system (Tanzania National website, 2001). It is designed to give two years of pre-primary education (kindergarten), seven years of primary education, and four years of junior secondary school, also known as Ordinary Level (O-level). Table 1 shows that the four years of O-level are followed by two years of senior secondary school, also known as Advanced Level (A-level).

The two years of kindergarten in Tanzania were formalized in 1995, but not mandatory; therefore, some students in some schools, especially in the rural areas, go straight to primary school. In general the Tanzanian education system has a total of nine years before secondary school and six years of secondary school before college or

university.<sup>1</sup> The American education system has a total of nine years (kindergarten to 8<sup>th</sup> grade) before secondary school (high school) and four years of secondary school before college or university (see Table 1).

Table 1

*Comparison of Education Systems in the United States and Tanzania*

	Primary	Elementary	Middle/Junior High	Secondary	
	K 1 2	3 4 5	6 7 8	9 10 11 12	
US	Age 5-6 6-7 7-8	8-9 9-10 10-11	11-12 12-13 13-14	14-15 15-16 16-17 17-18	
TZ	Pre-Primary	Primary		JSEC	SSEC
	K1 K2	1 2 3 4	5 6 7	9 10 11 12	13 14
	Age 5 6	7-8 8-9 9-10 10-11 11-12 12-13 13-14		14-15 15-16 16-17 17-18	18-19 19-20

*Key for United States (US):*

K: Kindergarten

Secondary: Also called “high school”

*Key for Tanzania (TZ):*

K1 & K2: First and second years of Kindergarten

JSEC: Junior secondary school (also known as “secondary school” or “ordinary level”)

SSEC: Senior secondary school (also known as “high school” or “advanced level”)

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<sup>1</sup> In Tanzania, we use the British education system. What the United States schools call “high school” we call “secondary school.”

It is important to note that although secondary education in both Tanzania and the United States begins at about age 14, in Tanzania it ends at about age 19-20 and in the United States at about age 17-18. Whereas a child in Tanzania has 15 years of school (2-7-4-2) prior to three or four years of tertiary education, in the United States a child has 13 years of school prior to university.

For more than 30 years, secondary education in Tanzania under the Ministry of Education and Vocational Training (MEVT) has made junior secondary school mathematics one of the five mandatory subjects for all students. Core subjects for junior secondary school curriculum offered by all schools are the following: Mathematics, English, Kiswahili, biology, civics, religion, history, geography, physics, and chemistry. The optional subjects include the following: home economics, information and computer studies, additional mathematics, music, fine arts, French, Arabic, Islamic studies, Bible knowledge, and physical education. All students in junior secondary schools should study at least seven subjects as a minimum number of subjects required for the Certificate of Secondary Education Examination (CSEE). The minimum number of seven subjects must be selected from the core list including mathematics, English, Kiswahili, biology, and civics. In senior secondary schools, students take a combination of either three science subjects or three arts subjects together with general studies. Senior secondary schools that do not have mathematics as one of the three core subjects still offer a general mathematics course, which is called subsidiary mathematics.

In Tanzania there are four mandated national assessments. The National Examination Council of Tanzania (NECTA) is responsible for the administration of all national examinations. All primary school pupils have to take the mandatory national

examination at the end of their seventh year. In the second year of junior secondary school there is a national assessment examination, which allows those who pass to continue to study for an additional two years to complete the four years of junior secondary school. In their fourth year students take the Form Four National Examinations or Certificate of Secondary Education Examination (CSEE).<sup>2</sup> The junior secondary school students spend at least ten days taking the examination. Each student is examined on at least seven subjects. The final grade of each subject is based on the total number of points earned out of 100. Students who attain 81-100 receive an “A,” students with 61-80 a “B,” students with 41-60 a “C,” students with 21-40 a “D,” and students with 0-20 an “F.” These standards were determined by the NECTA. Each grade is worth points as follows A=1 point, B=2 points, C=3 points, D=4 points, and F=5 points. The NECTA categorizes students into five divisions with the condition that a student did not receive an F in mathematics:

Division One is for those who got 7 to 17 points (best seven subjects)

Division Two is for those who got 18 to 21 points (best seven subjects)

Division Three is for those who got 22 to 25 points (best seven subjects)

Division Four is for those who got 26 to 33 points (best seven subjects)

Division Zero (failed) is for those who got 34 to 35 points (best seven subjects)

If a student receives an F in mathematics and has points worthy either of Division One or Division Two he/she will get Division Three instead. Some might think that with such a requirement by NECTA, both mathematics teachers and students would be

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<sup>2</sup> Form Four is equivalent to 12<sup>th</sup> grade in the United States.

encouraged to work hard for good mathematics final grades. However, mathematics performance in Tanzania is, in general, not good—especially for girls.

The CSEE allows those who pass to continue to the A-level. Two years later, students sit for the Advanced Certificate of Secondary Education Examinations (ACSEE). The ACSEE allows those who pass to continue to university or college studies. The entry to university or college is based entirely on the ACSEE results. In each group the assessments take place at the same time throughout the country. The primary school examination is a one-day examination, and it determines those to be admitted in the government (public) secondary schools. The private secondary schools then select from those who were not chosen to enroll in government secondary schools. Private secondary school teachers in Tanzania are better paid than the public secondary school teachers. Consequently, private schools have better teachers than public schools and hence they provide better education. Therefore, some families decide to take their children to private secondary schools even when their children get admitted to the government secondary schools. Students in Tanzanian schools have different backgrounds (economic and social). Social economic status of the student's family is one of the factors, which determine whether the student will go to public school or private school. Tanzanian government sees education as closely tied to social commitment.

Tanzania is a multilingual country with more than 130 tribal languages subdivided into 5 ethnic groups with different accents, customary practices, and value systems that determine largely the position and condition of women (Meena, 2003). As a

means of unifying these groups, Kiswahili was adopted as the official language.<sup>3</sup> Primary schooling is done entirely in Kiswahili with English as a subject. English is taught as a subject from standard three onwards, and it remains the medium of instruction in secondary schools and other institutions of higher learning. When pupils go to secondary school, there is a sharp switch from using Kiswahili as a medium of instruction to English. In other words, secondary school is done entirely in English with Kiswahili as a subject.

It is still a problem for most secondary school teachers to use only English throughout the class period, because either they are not fluent in English themselves or they fear that their students will not understand the instruction. Some mathematics teachers use both English and Kiswahili in the same lesson. However, the use of Kiswahili as a medium of instruction in secondary schools creates a problem, because education in Tanzania is nationalized and all national secondary school examinations are in English. Howie (2002) explored the performance of the South African pupils in mathematics and the relationship between mathematics achievement and the pupils' proficiency in English. Howie's (2002) research findings show that home language versus language of test influences students' performance in mathematics.

### **Purpose of the Study**

The purpose of this exploratory multiple case study is to allow me to begin to understand the mathematics achievement gap between boys and girls in Tanzanian secondary schools within the context of the teachers' teaching practices. Scholars have shown that improvement of FA contributes to the improvement of student learning,

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<sup>3</sup> Some English speakers know this language as Swahili; however, the language is correctly called Kiswahili.

especially in lower achievers (Black & Wiliam, 1998a; Meisels, Atkins-Burnett, Xue, Bickel, & Son, 2003). Scholars such as Samuelsson (2010) have shown that if mathematics teachers use PSA appropriately, that is, by paying attention to the social component of the classroom, PSA might help all students learn mathematics. Samuelsson (2010) examined the effect of two differently structured methods, traditional and problem solving, of teaching mathematics the first five years in school, as well as differences between boys' and girls' achievement depending on teaching approaches. The results show that "students' progress in conceptual understanding, strategic competence and adaptive reasoning is significantly better when teachers teach with a problem-based curriculum" (p. 61). The findings of the studies on teachers' instructional practices helped to inform this dissertation study.

This dissertation employs a multiple case study research approach. Three mathematics teachers, each from a different secondary school in the northwestern region of Tanzania, participated in this study. The case is the three teachers studied in this dissertation. Two of the three schools are private, and the third one is a government school. All the secondary schools are co-educational; that is, the school population comprises boys and girls. The data that were collected consisted of semi-structured interviews and classroom observations. All three teachers were interviewed and observed while teaching. I took field notes during the interviews, as well as during classroom observations. Data were collected, transcribed, and analyzed simultaneously. The analyses resulted in a description of the teachers' understanding of their teaching practices and instructional contexts and the description of the gender gap in mathematics in relation to the teachers' perceptions of their role in classroom contexts.

This dissertation has five chapters. The first chapter is the introduction. The second chapter is the literature review, in which I explain what the research tells us about the mathematics achievement gender gap in Tanzania and the role of PSA and FA practices in the teaching of mathematics. The third chapter is the methods chapter. In Chapter three I describe the observations, interviews, and the approach I used in the analysis and interpretation of the data. Chapter four focuses on the findings. Chapter four is divided into two main sections. The first section is on the teachers' understanding of their own teaching. The second section is on the description of how their understandings of their own instructional practices may perpetuate mathematics achievement gender gap. In Chapter five I give the synthesis of the empirical findings and then discuss the limitations of this dissertation study, the implications for teachers and teacher educators, the implications for policy makers, and the implications for future research.

## Chapter II

### Literature Review

As discussed in chapter I this dissertation seeks to answer the following questions:

(1) How do Tanzanian secondary school mathematics teachers' understandings of their own teaching reflect problem solving approach (PSA) and formative assessment (FA) in the context of their instructional practices? (2) How might their teaching practices, the perceptions of their teaching practices, and their classroom contexts perpetuate gender gaps in mathematics achievement? The literatures on gender gap, PSA and FA will inform how I will answer those questions. Unlike countries like the United States where research has suggested that the gender gap in mathematics has closed, the gender gap favoring boys in Tanzania is about 0.34 standard deviations (Masanja, 2004; Sutherland-Addy, 2008; Zilimu, 2009). Boys outperform girls in Tanzania in almost every subject (Kaino, 2009, September). The literature suggests that there is something happening in the classrooms that might contribute to the existence of gender gaps. The focus of this study is the Tanzanian secondary school mathematics teachers' perceptions of their role and classroom contexts, and how they teach in response to the contexts. I seek to understand how that perceived role in classroom contexts might perpetuate gender gaps.

This chapter is divided into three parts. The first section covers the gender inequity in mathematics education. This section covers the Tanzania education policy on gender equity in schools. I also discuss what the literature tells us about classroom interactions and gender. The second section is on the conceptual and analytic framework in which I discuss what research tells us about PSA and FA in terms of their effectiveness for promoting learning in low-achieving students. As an attempt to explain how PSA and

FA look like in practice I also describe the features of PSA and FA, which suggest relationships between the two instructional interventions. In the third section I describe the three-part lesson structure of PSA as an attempt to explain that PSA really needs FA in order to be done well.

### **Gender Inequity in Mathematics Education**

It is well documented that women in the field of mathematics remain underrepresented; the field of mathematics is male dominated (Snyder & Dillow, 2011). The questions are raised of why is this still happening in most parts of the world even if gender equity is highly promoted. Mendick's (2005) paper draws on a research study into why more boys than girls choose to study mathematics. She argues in this paper that choosing mathematics because one feels that they are good at it is not the only reason. Boys sometimes choose mathematics because they love to solve problems. The two reasons give students a sense of confidence. Lubienski and colleagues (2013) performed an extensive analysis of data from the Early Childhood Longitudinal Study-Kindergarten class of 1998-99 (ELCS-K). They found that "gender gaps in mathematical confidence were substantially larger than gaps in actual performance, with disparities in interest being smallest of all." (p. 637) Skaalvik and Skaalvik (2004) note that males may not perceive themselves as better in mathematics as in other subjects, but they still perceive themselves better than females at mathematics. What can we do to help girls gain mathematical confidence? According to Leedy, and colleagues (2003) the girls' lower self-assessment comes from the following influences: society, parents, and teachers. Correll (2001) also includes culture as a contributing factor of the girls' lower self-assessment.

As indicated in the early research study I conducted in three Tanzanian secondary schools from 2008 to 2009 (Zilimu, 2009), the teachers' classroom practices and classroom interactions may explain the gender gaps in mathematics achievement. Zhu (2007) reviewed the literature on gender differences in mathematical problem solving stating that "a large body of literature reports that there are gender differences in mathematical problem solving favoring males" (p. 187). Zhu (2007) also reports that the gender difference in mathematics results from a combination of factors including biological, psychological, and environmental. As environmental factors classroom contexts and instructional practices can play a role in shaping problem solving abilities among boys and girls. The results of Muthukrishna's (2010) study on gender gap in mathematics achievement at a rural primary school in South Africa's KwaZulu-Natal showed that there was a gender gap in sixth grade. According to Muthukrishna one of the factors associated with the gender gap in mathematics achievement was classroom practice.

Research on gender and mathematics achievement reports differences in mathematics performance between girls and boys in terms of levels in schools and mathematics content strands. Some studies have established that there are small but consistent gender differences in mathematics achievement in primary, middle, and high school years, with gaps of about 0.1 standard deviations (McGraw, Lubienski, & Strutchens, 2006; Perie & Moran, 2005; Rampey, Dion, & Donahue, 2009). The difference appears in favor of males when the tests administered involve higher-level cognitive tasks, and the difference is in favor of girls when the tests involve lower-level cognitive tasks (McGraw & Lubienski, 2007; Tartre & Fennema, 1995; Vasilyeva,

Casey, Dearing, & Ganley, 2009). Some early studies report that, in general, gender differences in mathematics achievement become more compelling in favor of boys in secondary schools and beyond (Fennema & Sherman, 1978; Fierros, 1999, April; Hyde, Fennema, & Lamon, 1990; Mullis, et al., 1998; Mullis & Stemler, 2002). Mullis and Stemler (2002) state that “considerable research, including the findings from TIMSS, has shown that as students get older, gender differences favoring males increase both in mathematics and science” (p. 277).

According to Masanja (2004), the difference between girls’ and boys’ performance in Tanzania secondary schools is extreme across all subjects, and it is even bigger in mathematics and science.

Table 2

*Gender Performance in Mathematics in the Form Four National Examinations in Tanzania, 2000*

[Letter] Grades	A	B	C	D	F
Male	1,528	10,626	21,425	33,079	123,965
%	82.11	73.37	64.13	54.91	44.32
Female	333	3,857	11,984	27,168	155,715
%	17.89	35.87	26.63	45.09	55.68
Total	1,861	14,483	33,409	60,247	279,680

Table 2 (Sutherland-Addy, 2008) indicates that the performance of girls in the form four national examinations in Tanzania is generally below that of boys. For instance 82.11 percent of the students who got A were boys versus 17.89 percent who were girls. More girls than boys failed mathematics (55.68 percent of the students who got F were girls). For more than ten years numerous people in the Tanzania government and

education system have tried different ways, including changing the mathematics curriculum, to reduce the achievement gap. Meena (2003) noted that one of the goals of the 1999 Ministry of Education and Culture policy is to promote girls' secondary education by revising the curriculum to strengthen the performance of girls in mathematics and science. Tanzania's education and training policy has defined gender equality as a main anchor of its policy (Meena, 2003). However, the gender gap is still an educational problem. For example, Saito (2010) used SACMEQ (Southern and Eastern Africa Consortium for Monitoring Educational Quality) data for the 15 countries that participated in the study and found that four countries (Tanzania, Kenya, Malawi and Mozambique) where boys performed significantly better than girls in mathematics in 2000 were the same countries where boys performed better than girls in 2007. In my early research study (Zilimu, 2009) I confirmed that a mathematics achievement gap between boys and girls still exists in Tanzania secondary schools. The qualitative results in the same early research study suggest that there might be a relationship between the teachers' instructional practices and the achievement gap.

Sadker (1999) explains that teachers are more likely to engage boys in conversation in the classroom. Part of this dissertation study looked for favoritism during classroom observations. If classroom discussion favors some students, especially the fast learners, then the slow learners lose confidence, both in understanding mathematics and in classroom participation. Empson (2003) states that, "if the participant frameworks that emerge in classroom interactions consistently position certain students outside of the practices that the teacher takes to represent mathematical competence, one may expect student disengagement as a direct consequence" (p. 318). This practice reduces the low

achievers' access to mathematics power. In this respect, mathematics education takes on a "political or social agenda—who has mathematical power and who do not" (Moody, 2001, p. 274). We can expect the low-achieving students to participate fully in the mathematics discussion, be it in small or in big groups (whole class) if we (teachers) give them access to mathematics power by showing them that we value their mathematics thinking by explaining what they are expected to do and by giving them opportunities to share their strategies with their peers (Van de Walle, Karp, & Bay-Williams, 2010).

Most mathematics education scholars believe that teaching through problem solving plays a central role in the process of effective teaching of mathematics. There are different versions of teaching through problem solving. In this dissertation study I focus on one of the versions—using the model put forth by Van de Walle (2001). Van de Walle (2001) argues that since teaching through problem solving requires a teacher to make the atmosphere and the lesson work, a lesson should consist of three main parts: *before*, *during*, and *after*. The three-part lesson format will be explained later in this chapter. The term teaching through problem solving is used when researchers are referring to mathematical tasks that have no prescribed set of rules or procedures that would help students to generate a solution (Cai & Lester Jr, 2010; Hiebert, et al., 1997). Hiebert and colleagues (1997) say that problem solving is a task or activity that has the potential to provide intellectual challenges for enhancing students' mathematical understanding, and they define a problem as any task or activity that has the following features: has no one correct solution, begins with students' current understanding, engages students and helps them to make sense of the mathematics involved, and requires the students to justify and explain their methods and answers. This is the definition of a problem or worthwhile task

that I employ in this dissertation study. In this dissertation study I use PSA and teaching through problem solving interchangeably.

When students engage in solving mathematically rich problems, they develop problem solving skills and so learn and understand mathematics concepts and procedures (Schroeder & Lester, 1989). If teachers want to help students learn and understand mathematics, they have to use an instructional approach that makes problem solving an integral part of mathematics learning. This instructional approach is often called teaching through problem solving, in which students learn and understand mathematics through engaging in solving mathematically rich problems.

Mathematically rich problems extend beyond computational problems and enable students to formulate an understanding of mathematical concepts that integrate both conceptual and procedural knowledge. For instance Lampert's (1990) fifth grade students engaged in solving questions about exponents, and she reports that "students asserted various hypotheses about how to figure out the last digit in  $5^4$ ,  $6^4$ , and  $7^4$  without multiplying . . . Two competing hypotheses about how exponents work were revealed in their assertions about the last digit in  $7^5$ " (p. 39). The application of the knowledge about exponents in  $4^{\text{th}}$  power to a larger domain is an indication of conceptual understanding and improvement of problem-solving capacity.

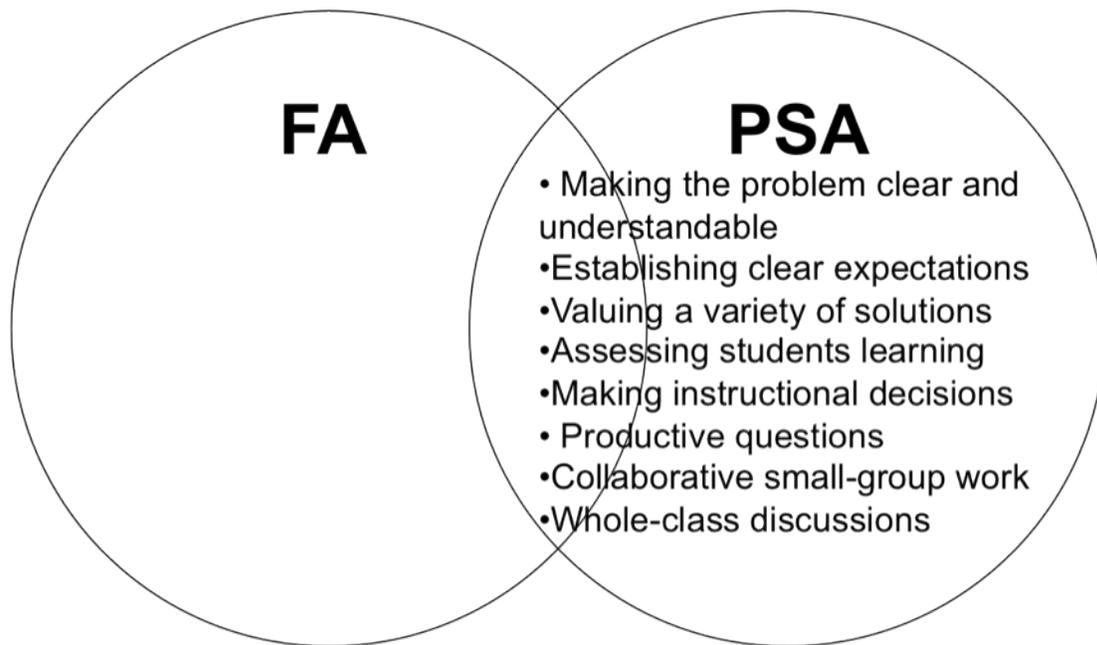
Similarly, Cowie and Bell (1999) observe that there has been an increased focus on classroom assessment, especially its formative role of improving teaching and student learning while instruction is taking place. Research conducted around the world at all levels of instruction shows evidence of strong achievement gains in student performance when formative assessment permeates the classroom environment (Black & Wiliam,

1998a; Brookhart, 2001; Brookhart, Andolina, Zuza, & Furman, 2004; Meisels, et al., 2003; Rodriguez, 2004; Ruiz-Primo & Furtak, 2006). The most intriguing result is that teachers who use formative assessment methods effectively improve their students' learning, especially students with the lowest achievement. Ruiz-Primo and Furtak (2006) conducted a qualitative case study with some statistical data in the section where they "link the teachers' informal assessment practices with student performance" (p. 226). Ruiz-Primo and Furtak's (2006) study used a framework that shows the nature of student–teacher interaction in classroom assessment. Four middle school science teachers participated in this study. The authors explored each teacher's questioning practices by observing the whole-class discussions as assessment conversations. The assessment conversations in Ruiz-Primo and Furtak's (2006) study consisted of four stages: "the teacher asks a question to elicit student thinking, the student provides a response, the teacher recognizes the student's response, and then uses the information collected to support student learning [ESRU cycle]" (p. 207). The results in this study show that students in classrooms where teachers engaged in classroom discussions that were more consistent with this model performed significantly higher on embedded assessments and post-tests. However, the use of a very small sample size (four teachers) is a methodological issue in Ruiz-Primo and Furtak's (2006) study, which prevents generalizing the findings beyond the participants of the study.

Black (1993) defines formative assessment as assessment for learning and not assessment of learning. The term formative assessment in this dissertation study refers to the collaborative processes engaged in by teachers and students in which teachers frequently assess students to understand their learning, identify their strengths, diagnose

their weaknesses, and use the results to plan the next steps in instruction (Black & Wiliam, 1998a). This is the definition of FA that I employ in this dissertation study. I use the PSA and FA frameworks in this dissertation to guide my classroom observations and teacher interviews, because I believe that the integration of PSA and FA in a mathematics classroom is a richer way of capturing effective mathematics teaching and that it comprises processes such as the use of real world problems and establishment of clear expectations that may lessen gender inequities. Girls tend to perform better when questions asked are real world problems (Forgasz, et al., 2010; Hyde, et al., 2008; Pomerantz, et al., 2002).

### **Conceptual Framework**



The Venn diagram represents the instructional practices, which appear in both FA and PSA.

FA and PSA overlap in features like making the problem clear and understandable, establishing clear expectations, valuing a variety of solutions, assessing students' learning, making instructional decisions, asking productive questions, and use of small and whole class discussions. According to Van de Walle and colleagues (2010) teaching through problem solving “generally means that students learn mathematics through real contexts, problems, situations, and models” (p. 32). Learning mathematics through solving real context problems is a characteristic of PSA that seems particularly good for girls. Research suggests that girls tend to perform better when tests are closely tied to school taught materials (Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Pomerantz, Altermatt, & Saxon, 2002).

In 1980 the National Council of Teachers of Mathematics (NCTM, 1980) suggested that, “problem solving be the focus of school mathematics” (p. 1). The common form of problem solving has been the one in which the teacher teaches the concepts and procedures first and then assigns problems that are designed to provide practice on the learned concepts and procedures. Such an approach does not help students to understand mathematical ideas (conceptual understanding). For example, Larkin (1989) showed that students in the traditional classroom failed to apply simple computational skills when problems changed slightly or when the same problems were asked in different contexts; this reveals a lack of conceptual understanding necessary for knowledge application.

FA directly addresses the instructional practices that facilitate mathematical understanding. Influential documents such as the *Assessment Standards for School Mathematics* by the National Council of Teachers of Mathematics (NCTM, 1995) support

classroom assessment practices in which teachers use evidence of students' mathematical understanding, along with other evidences from the instructional process, to modify instruction so that it will better facilitate students' learning. The following two subsections briefly provide explanations of some features of PSA and FA.

### **The Features of PSA.**

Schroeder and Lester (1989) identified three ways that mathematics teachers might incorporate problem solving into mathematics instruction. First is teaching for problem solving; this approach can be summarized as teaching the mathematical skills (for example abstract concepts and algorithms) first and then a student applies the learned skills by solving problems. Second is teaching about problem solving: this approach involves teaching students the process or the strategies for solving a problem. Third is teaching through problem solving: in this approach students learn mathematics through real contexts, situations, and models.

In this dissertation, I use PSA to mean teaching through problem solving and not teaching for problem solving nor teaching about problem solving. Research on teaching through problem solving (Hiebert & Wearne, 1993; Marcus & Fey, 2006; Van de Walle, 2003) reveals that problem-solving instruction supports student learning. The features of PSA I looked for as I did classroom observations and interviewed the teachers were the following: Creating meaningful and engaging contexts, allowing multiple paths to the solution, letting students do the talking, and providing ongoing assessment data useful for making instructional decisions.

Providing students with a context that is grounded in an experience familiar to them supports the development of mathematics concepts (Van de Walle, et al., 2010).

One of the teacher's roles is to begin the lesson with problems that will get students excited about learning mathematics. Teachers should help students develop confidence that they are capable of doing mathematics and that mathematics makes sense.

Sometimes when a teacher poses a problem-based task and expects a solution, he or she needs to say to students that he or she believes they can do this question.

A good problem-based task allows a student to make sense of the task using his or her own ideas. PSA does not dictate how a student must think about a problem in order to solve it. When the teacher poses a task he or she should encourage the students to use their own ideas to solve the problem because a problem for learning mathematics begins where the students are. In other words the selection of the task takes into consideration the students' current understanding. PSA is characterized by the teacher helping students to develop a deep understanding of mathematical concepts and methods by engaging them in solving problematic tasks (mathematically rich problems) in which the mathematics to be learned are embedded. Hiebert and Wearne (2003) state that, "allowing mathematics to be problematic for students means posing problems that are just within students' reach, allowing them to struggle to find solutions and then examining the methods they have used" (p. 6). Beginning with the students' current understanding, the teacher engages the students in a problem solving activity that gives them an opportunity to develop new mathematical understanding and requires them to justify and explain their strategies and answers (Hiebert, et al., 1997).

When the teacher poses a task he or she should let the students understand that one of their responsibilities is to prepare for a discussion that will occur after working on the problem. The teacher directs the students to spend a few minutes developing their

own thoughts and ideas on how to approach the task. Then he or she puts them in small groups in order to discuss each other's strategies. Small groups provide an opportunity for students to verbalize their questions and thinking, to test out ideas and to practice articulating them (Grouws, 2003; Van de Walle, et al., 2010). The role of small groups in teaching through a problem solving approach is to facilitate mathematical discussions. During discussion the students get an opportunity to describe and evaluate solutions to tasks, share approaches, and make conjectures.

Hiebert and Wearne's (1993) study showed that students in an alternative class, in which students were asked questions requesting them to describe and explain alternative strategies and talk more using longer responses, showed higher levels of performance than their more traditionally taught peers. Despite the differences regarding the conditions for PSA to be effective, many if not all PSA researchers as well as policy makers agree that problem solving instructions promote students' mathematical learning.

Wirkala and Kuhn (2011) reported results of a highly controlled experimental study of problem-based learning that they performed in a middle school population. They compared performances of students learning the same material under three different conditions: lecture/discussion, characteristic small group problem-based learning, and solitary problem-based learning. The results showed that students in the two problem-based learning conditions performed better than the students in the lecture condition. However, Wirkala and Kuhn (2011) are not enthusiastic about the social component of problem-based learning, because their study's results also show that there was equivalent performance in the small group problem-based learning conditions and the solitary problem-based learning. For Wirkala and Kuhn (2011), these results suggest that the

social component of problem-based learning is an important but not a necessary condition. However, for the purpose of this dissertation I also paid attention to the social component of PSA.

PSA provides ongoing assessment data useful for making instructional decisions to help students succeed. During the discussion phase of teaching through problem solving approach, students get opportunities to discuss their own ideas and thinking, to defend their solutions and to evaluate those of others. Discussions provide the teacher with a better understanding of how students solve problems, how they connect and apply new concepts and what misconceptions they might have. The teacher can use these learning evidences to make instructional adjustments and accommodate each student's learning needs while instruction is going on.

#### **The features of FA.**

For more than 20 years, the improvement of formative assessment practices in curricula has been considered as a way to make strong contributions to the improvement of student learning, especially in students with the lowest achievement (Black & Wiliam, 1998a; Fuchs, Fuchs, Karns, Hamlett, & Kataroff, 1999; Meisels, et al., 2003). After reviewing more than 250 articles related to formative assessment, Black and Wiliam (1998a) drew the conclusion that formative assessment improves student learning. Each study in this meta-analysis uses effect size to describe the difference between the means of experimental and control groups.

From the quantitative studies, Black and Wiliam (1998a) derived the effect size for learning gains across student achievement levels between 0.4 and 0.7 (Black & Wiliam, 1998b). In their follow-up article, Black & Wiliam (1998b) conclude that “these

effect sizes are larger than most of those found for educational interventions” (p. 141). The most encouraging finding was that the achievement gains were highest for lower achieving students. Black and Wiliam (1998a) acknowledge that their choice of the studies that are based on quantitative comparisons of learning gains does not “imply that useful information and insights about the topic cannot be obtained by work in other paradigms” (p. 5). Furthermore, Black and Wiliam (1998a) conclude “there is clearly a need for a combination of such measures with richer qualitative studies of processes and interactions within the classroom” (p. 26). Since the publication of Black and Wiliam (1998a), significant quantitative and qualitative empirical studies have been performed to show that formative assessment is effective in improving student learning and raising student achievement.

Researchers in the area of formative assessment (Black & Wiliam, 1998a, 1998b; Leung & Mohan, 2004; Ruiz-Primo & Furtak, 2006, 2007; Stiggins, Arter, Chappuis, & Chappuis, 2006) list frequent checking of student understanding, descriptive feedback, self-assessment and peer-assessment, student involvement in assessment, and classroom discussions as some of the features of FA that secure the evidence about the effectiveness of formative assessment. This evidence guided the collection and analysis of the data in this dissertation study.

One of the characteristics of formative assessment practices is to assess students frequently and use the results to plan the next steps in instruction. Frequently checking student understanding, which is also referred to as monitoring student learning in the classroom, involves all activities pursued by teachers to keep track of student learning for purposes of making instructional decisions and providing feedback to students on their

progress. Brophy (1979) reviews the research on the relationship between teacher behaviors and student achievement. He refers to monitoring as an essential feature of an effective teacher. Some research literature defines formative assessment as a set of tools to monitor student progress during learning (Dunn & Mulvenon, 2009; Stiggins, 2002).

There are many methods used by the teacher to monitor student learning. For the purpose of this dissertation I am interested in questioning students during discussions, circulating around the classroom during seatwork, assigning and correcting homework, reviewing student performance data collected and recorded and using the data to make adjustments in instruction. Any set of activities or tools qualifies as formative when the information is used to inform or adapt instruction (Black & Wiliam, 1998b; Perie, et al., 2007).

Wininger (2005) examined the effect of formative summative assessments on the second administration of “a 50-item Educational Psychology exam consisting of true-false, multiple choice, labeling, and matching items as the measure of achievement” (p. 165). Seventy-one students (mostly females—57 girls) participated in the study. The 71 students were enrolled in two sections of educational psychology. The second section with 37 students served as the control group. Wininger’s (2005) study answers the research question, “Is going over exams in class with students and gathering both quantitative and qualitative feedback from the students about their comprehension a valuable aid to student learning?” (p. 164). The quantitative feedback was gathered by using a five-item survey. The students anonymously completed the survey after receiving feedback on their second exam. They used a five-point Likert scale to respond to the five items in the survey. In this study, Wininger (2005) used a treatment group of 34 students

and a control group of 37 students. Students in the treatment group received feedback from the teacher and classmates, and they were guided in the self-assessment of their performance. The students in the control group only received a copy of their exam with the information as to what questions they had missed, but they did not receive other feedback or guidance for self-assessment. One week later the initial test was administered again to the two groups, and they all showed significant gains. However, the treatment group significantly outperformed the control group. The treatment group gained 9.41 points from their initial score and the control group gained only 2.10 points.

Wininger's (2005) study had its origin in the idea of mastery learning. Each student in the treatment group received feedback and corrective information that gave the students detailed information of what needed to be done next to master the concepts in the exam. Wininger's (2005) study provides support for using formative assessment to improve student learning outcomes. However, a few methodological issues were noted in this study. First, the sample size was too small to give a precise hypothesis testing. The small sample size also resulted in an inability to generalize the results beyond the participants of the study. Second, the researcher's use of his own students could have led to a researcher bias.

Brookhart and colleagues (2004) conducted an action research study of student self-assessment in which the participants were two university supervisors, three student teachers, and three cooperating teachers with two classes of a total of 41 students. This action research study was used in classrooms whose curriculum involved memorizing the math facts, times tables to be specific. Brookhart and colleagues (2004) explain that "the primary purpose of this action research study was to see whether student self-assessment

in the service of this required, rote activity would add desirable outcomes besides simple knowledge of math facts” (p. 213). The results show that student self-assessment was successful at turning the rote memorization task of learning the times tables into a deeper experience for students about monitoring their own mathematics learning.

Brookhart and colleagues’ (2004) action research on student self-assessment was driven by mastery goal orientation as opposed to performance goal orientation. This study links to work by Dweck (1986) who postulated that children with mastery learning goals approach situations with the goal to master the acquisition of new skills, while children with performance goals approach situations with the goal of gaining approval from peers and teachers. Brookhart and colleagues’ (2004) study reports that “students enjoyed participating in self-assessment” (p. 225) and they were able to attain the mastery goal orientation to learning. From the teacher interviews, Brookhart and colleagues (2004) found that self-assessment practices helped to improve students’ mathematics learning and also student achievement was higher than in the previous years (p. 225). Research reveals that students’ perspectives on classroom assessment are very important for FA practices.

Brookhart (2001) conducted a qualitative study that investigated successful students’ formative and summative uses of assessment information. Brookhart’s (2001) study answers the following research questions: “What does formative assessment look like when considered from the students’ point of view? What are students’ views of the purpose, usefulness, relevance, and importance of specific classroom assessments and their performance on those assessments?” (p. 158). Students from 10th and 11th grade English classes and 12th grade anatomy classes were selected to participate in the study.

The researcher made initial observations in each class and made note of the general instructional practices. Pre- and post-surveys were administered for each classroom assessment event observed. Four to ten students per classroom assessment event were interviewed; 28 interviews in English classes and 24 interviews in anatomy classes were conducted with a total of 50 different students. Successful students talked about using assessment information formatively. They considered participating in the assessment processes as an instance of learning. Brookhart (2001) states, “students were aware of how what they were working on contributed to their learning both when they liked their assignment and when they didn’t” (p. 162). Although Brookhart (2001) is not a study about the causality, it supports the positive contribution of formative assessment to student learning and achievement. Brookhart’s (2001) study was driven by constructivism, the theory of learning that views learning as a process in which the learner actively constructs or builds new ideas or concepts.

The use of only successful students in Brookhart’s (2001) study is a methodological issue. The main concern is that if the low-achieving learners were the participants, would they have had the same positive experiences of formative assessment practices as the successful students had. It is very hard to generalize the results.

### **Integrating PSA with FA to Help Close the Gender Gap**

Researchers and mathematics curriculum developers alike tend to agree that the PSA to teaching mathematics creates an opportunity for the teacher to assess what his or her students are learning and where they are experiencing difficulty (Cai & Lester Jr, 2010; Lappan & Phillips, 1998; Ziebarth, 2003). Van de Walle and colleagues (2010) explain how formative assessment appears in a PSA as follows:

As students discuss ideas, draw pictures or use manipulatives, defend their solutions and evaluate those of others, and write reports or explanations, they provide the teacher with a steady stream of valuable information. These products provide rich evidence of how students are solving problems, what misconceptions they might have, and how they are connecting and applying new concepts. With a better understanding of what students know, a teacher can plan more effectively and accommodate each student's learning needs (p. 34).

Assessment is a general term used to refer to all activities teachers use to help students learn and to gauge student progress (Black & Wiliam, 1998b). In this dissertation study, I focus on formative assessment, "the kind of [classroom] assessment that can be used as a part of instruction to support and enhance learning" (Shepard, (2000), p. 4) as opposed to summative assessment, "the kind of [classroom] assessment used to give grades or to satisfy the accountability demands of an external authority" (Shepard, 2000, p. 4). I believe that FA should be part of a PSA because research evidence suggests that teachers who use PSA need to pay close attention to FA in order to help all students develop a deep understanding of mathematical concepts and methods (Fuchs, et al., 1999; Wirkala & Kuhn, 2011). However, the research on PSA does not emphasize FA.

To illustrate the complementarity of PSA and FA, I used Van de Walle's (2001) three-part problem-based lesson because Van de Walle offers a scheme or structure for thinking about a lesson using PSA. The three-part model sheds light on the opportunities for FA in PSA. The three components of problem-based lesson are *before*, *during* and *after* (See Table 3). FA in general is key for the teacher in the three-part model for

teaching mathematics through problem solving. These planning steps for a problem-based lesson are important because they will determine the questions to be asked concerning teachers' decisions about how they design lessons.

Table 3

*Planning Steps for a Problem-based Lesson.*

Content and Task Decisions	Lesson Plan	Reflecting on the Design
1. Determine the mathematics and goals	5. Plan the BEFORE activities	8. Check for alignment within the lesson
2. Consider your students' needs	6. Plan the DURING questions	9. Anticipate student approaches
3. Select design, or adapt a task	7. Plan the AFTER discussion.	10. Identify essential questions
4. Design lesson assessments		

Table 3 is adapted from Van de Walle, Karp and Bay-Williams (2010) page 59.

Information about student background that influences lesson planning is helpful for discerning gender difference. PSA to teaching mathematics involves teachers and students working cooperatively to solve a mathematical task, and the skills emerge from working with problems. Some researchers have argued that girls tend to prefer cooperation instead of competition; they work with others and build on others' ideas; they are more likely to acknowledge others' contributions (Kelly, 2002; Sadker, 1999; The Mid-Atlantic Equity Consortium, 1993). It is very important to note that not all girls will have a single preferred approach to learning or one set of education needs. Some female students may not fit the criteria mentioned earlier. These criteria are generally true, but will not fit all cases.

### **FA in the three-part model of PSA.**

Van de Walle (2001) suggests that a problem solving lesson should always have three parts: *before, during, and after* (steps 5, 6 and 7 in Table 3).

In the before part of the lesson, the teacher gets students ready. It is the teacher's responsibility to get students mentally ready to work on the mathematics task and to make sure that all expectations for products are clear. Similarly, strategic use of FAP requires that teachers plan well the instruction to help teachers and students together achieve the learning goals. Brookhart (2001) explains, "teacher intentions and uses, of course, are realized in instructional planning and other aspects of teaching" (p. 155). The teacher begins instructional planning by listing the desired objectives and outcomes and he or she chooses the tasks that will help achieve the intended outcomes. The teacher then communicates the instructional goals to the students to get them involved in the assessment practices (Stiggins, et al., 2006).

In the during part of the lesson the teacher gives students a chance to work without his or her constant guidance so that students can apply the ideas and strategies they came up with in the before part. In this phase, the teacher becomes an active listener and observer. The teacher observes students working on the task and assesses how the students are approaching the problem. The teacher is expected to offer hints, guide, coach, and ask insightful questions and share in the process of solving problems without falling back into directed teaching (Lester, et al., 1994). Such characteristics of a PSA provide the teacher with useful evidence of students' understanding. Hence, FA at this stage of the instruction will give the teachers the flexibility to adjust their instructions to help student learning while the instruction is taking place. In other words, when the

teacher conducts formative assessment during the time the students are engaged in solving problems, he or she uses the FA results either to adjust instructions to accommodate each student's needs while instructions are going on or to plan his or her next steps in instruction to improve student learning. Stiggins and colleagues (2006) describe the formative assessment or assessment for learning as "the assessments that we conduct throughout teaching and learning to diagnose student needs, plan our next steps in instruction, provide students with feedback they can use to improve the quality of their work, and help students see and feel in control of their journey to success" (p. 31).

The after part of the lesson is the time for whole class discussion. The students get to discuss, justify, and challenge various solutions to the problem. It is the teacher's role to plan enough time for the after part of the lesson because most of student learning takes place during this portion of the lesson. In reform-based mathematics instruction, students are given a larger role in classroom discussion. Groups or individuals are given opportunities to share their solutions with the rest of the class. As the students explain their ideas and strategies, the teacher learns how the students perceive the problem situation (Chazan & Ball, 1999).

PSA provides opportunities for teachers to assess students formatively because the learning environment of PSA provides a natural setting for students to present various solutions to their group or class and learn mathematics through social interactions. Van de Walle (2001) states that "much more learning occurs and much more assessment information is available when a class works on a single problem and engages in discourse about the validity of the solution" (p. 44).

FA as well as PSA considers students as active learners, not just test takers. Formative assessment instructional planning involves students and gives them opportunities to think about their own learning (Brookhart, 2001). The whole FA process helps the teacher identify the gap between a student's current status in learning and the desired learning objectives. FA helps teachers monitor their students' progress and modify the instruction accordingly. The continuous assessment of the students reveals each student's location (where each student is now), and the teachers use these learning evidences to make instructional decisions and adjust instruction as needed to improve student learning.

During classroom discussion, teachers are encouraged to be good listeners and accept student solutions in a non-evaluative way. *Principles and Standards for School Mathematics* (NCTM, 2000) explains that "effective teaching involves observing students, listening carefully to their ideas and explanations, having mathematical goals, and using the information to make instructional decisions" (p. 19). The teachers' roles in classroom discussion are to control the amount of time used on discussing a certain mathematics concept and to guide students at the times when they go off the intended mathematical concepts to be learned. In other words, teachers should know when it is appropriate to intervene and when to step back and let the pupils make their own way (Lester, et al., 1994).

Evidences from research on the teaching and learning of mathematics suggest that if PSA teachers pay close attention to FA it might help all students to develop a deep understanding of mathematical concepts and methods (Fuchs, et al., 1999; Hiebert & Wearne, 1993; Wirkala & Kuhn, 2011). For instance, Hiebert and Wearne (1993)

investigated relationships between teaching and learning mathematics in the six second-grade classrooms in one school, and the results suggest that relationships between teaching and learning mathematics are a function of the instructional environment. In their study, Hiebert and Wearne (1993) “focused on the tasks or problems presented to the students and the nature of the classroom discourse” (p. 395).

### **Summary**

Although it is possible for PSA and FA to be done independent of one another, they can and perhaps should be complementary. The role of FA to inform the teachers’ decisions as they adjust their instructions to meet students’ needs is not yet emphasized in the PSA literature; however, the opportunities for FA in the PSA instruction can be noticed in the second and third parts of the three-part lesson structure of PSA. When FA is an integral part of instruction, it contributes significantly to students’ learning (Ruiz-Primo & Furtak, 2006, 2007). The information obtained from FA helps teachers to think about their teaching in new ways and to adjust their instructions to meet students’ needs.

Classroom discussion as expressed in a PSA and FA practices may be used by teachers as a tool to better grasp the learning needs of their students: what they know, misconceptions they may have, and how these might have developed. Piccolo and colleagues (2008) observed, coded, and analyzed middle school algebra, number, and data lessons using a grounded theory approach. The results of Piccolo and colleagues’ (2008) study indicate that when students engage in rich, meaningful mathematical dialogue, the teachers tend to provide more detailed explanations and give examples that help students’ understanding of mathematics concepts. The key feature of FA incorporated in a PSA is that the teacher, using real-life problems, finds ways to help

students to be active in the classroom and to speak out, express their ideas, and be persistent in asking questions. Until that happens the teacher does not know what is needed to improve student learning.

## Chapter III

### Research Methods

This dissertation study follows from a pilot study that investigated Tanzanian boys' and girls' mathematics achievement on secondary school national examinations (Zilimu, 2009). Three mathematics teachers, each from a different secondary school in the northwestern region of Tanzania, participated in the pilot study. Quantitative data (Certificate of Secondary Education Examination results of 2008 and survey) were analyzed and a comparison was made of the mean of the boys' mathematics scores and the mean of the girls' mathematics scores of all participating students. These results indicate that there was a statistically significant difference between the mean of boys' scores and the mean of girls' scores in national mathematics examination results. Results from the qualitative data (classroom observations) indicated that the teacher with the largest gender gap used formative assessment (FA) less frequently than the other two teachers. The findings indicate that there might be a relationship between gender gap and teachers' instructional practices. The results of the pilot study led to this dissertation study, which explores the nature of the gender gap in Tanzanian secondary school mathematics classrooms.

A case study research approach was chosen for this dissertation study because I seek greater understanding of the teachers' knowledge of their instructional practices, classroom contexts, and the gender gaps in relationship to problem solving approach (PSA) and FA practices. Stated differently, I seek to investigate the following questions: (1) How do Tanzanian secondary school mathematics teachers' understandings of their own teaching reflect PSA and FA in the context of their instructional practices? (2) How

might their teaching practices, the perceptions of their teaching practices, and their classroom contexts perpetuate gender gaps in mathematics achievement?

The gender achievement gap in mathematics is a current problem in the secondary school education system in Tanzania. This dissertation seeks to understand the essential nature of the gender gap within the classroom context, and it employs qualitative case study research as defined by Merriam (1997), “A qualitative case study is an intensive, holistic description and analysis of a bounded phenomenon” (p. xiii), and Yin (2009) who, defining case study as a research method, provides its two critical features as part of a twofold, technical definition of case studies;

(1) A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident; (2) The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis (p. 18).

The process of exploring the gender gap in Tanzanian secondary school mathematics classrooms and understanding teachers’ perspective on the use of PSA and FA in their own classrooms was best accomplished as an interpretive task using case study methodology. Case study is a qualitative inquiry approach that was a good fit for this dissertation study because it addresses the “how” and “why” questions of schooling and classroom contexts that influence the gender gap. According to Yin (2009) a case

study design should be considered when: (a) the focus of the study is to answer “how” and “why” questions; (b) you cannot manipulate the behavior of those involved in the study; (c) you want to cover contextual conditions because you believe they are relevant to the phenomenon under study; or (d) the boundaries are not clear between the phenomenon and context.

Case study methodology emphasizes interpretation because during the whole process of collecting, analyzing and writing the report of the study the researcher objectively records “what is happening [in the field in which the researcher is observing the workings of the case] and simultaneously examines its meaning and redirects observations to refine or substantiate those meanings” (Stake, 1995, pp. 8-9). PSA and FA frameworks informed this study. I paid close attention to the rigor and trustworthiness of the research design and its implementation. To increase the trustworthiness of this dissertation study I first did a pilot study in 2008-2009 (Zilimu, 2009) with the three Tanzanian secondary school mathematics teachers who participated in this study. The teachers were my informants. I remained in touch with them through emails and phone calls and I paid some visits with them between 2008 and 2013. I spent an extended period of time with my informants, though not physically, to allow them to become accustomed to me. This is one of my credibility strategies.

The second credibility strategy was the use of multiple data collection methods. I used classroom observations, semi-structured interviews and field notes to collect data. This is a methodological triangulation (Denzin, 1978) in which the data I collected by classroom observations, semi-structured interviews and field note were compared. Triangulation is a powerful strategy for enhancing the quality of the research, particularly

credibility. Krefting (1991) explains that, “triangulation is based on the idea of convergence of multiple perspectives for mutual confirmation of data to ensure that all aspects of a phenomenon have been investigated” (p. 219).

The third credibility strategy was member checking. I used member-checking approach to allow the teachers to recognize their experiences in my dissertation study findings. I played some parts of the audio taped interviews to the teacher after each interview for his responses. Following Lincoln and Guba’s (1985) suggestions, I continually shared with the teachers my data, the analytic categories, interpretations, and conclusions.

In this chapter I discuss the research design, context of the study and its participants, data collection and data analysis.

### **Research Design**

This case study research took place in the mathematics classrooms at three of the secondary schools in the northwestern corner of Tanzania. One teacher from each of the three schools participated in this study. The names of the three teachers and of the three schools are Mr. Isidor from Mwanzoni Secondary School, Mr. Leo from Kasheshe Secondary School, and Mr. Patrick from Bunge Secondary School.<sup>4</sup> Each of the three mathematics teachers participated in the previously conducted early research study, which I used as a pilot study for this dissertation, and indicated interest in continuing as a primary participant for this dissertation study. Each of the three participants (mathematics

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<sup>4</sup> The names of the teachers and of the schools are pseudonyms: The names of the teachers are in alphabetical order starting with the most experienced teacher from highest performing school to the least experienced teacher from the medium performing school (Isidor, Leo, Patrick).

teachers) is the case for this dissertation study. I used the gender achievement gap to select my cases. The national examinations council of Tanzania lists the three schools as high achieving schools; however, Table 4 shows that the difference between achievement gender gaps of the teachers is big (Zilimu, 2009).

Table 4

*Gender Achievement Gaps at the Three Secondary Schools*

Teacher	School	Achievement gap
Isidor	Mwanzoni	6%
Leo	Kasheshe	13.5%
Patrick	Bunge	78%

The cases are mainly bounded by northwestern Tanzania secondary school mathematics classroom context in which the teachers themselves and their understanding of the gender gap emerge into the teachers’ own teaching practices. Through qualitative case study research techniques, the qualities or the essential nature of the gender gap in mathematics achievement in relation to the teachers’ teaching practices were uncovered.

More specifically this dissertation study may be considered a multiple case study (P. Baxter & Jack, 2008; Yin, 2009). According to Baxter and Jack (2008), “In a multiple case study, we are examining several cases to understand the similarities and differences between the cases” (p. 550). Each teacher is instrumental to understanding the existence of the mathematics gender gap in Tanzania secondary schools. One of the issues in this dissertation study is the mathematics teachers’ experience of the mathematics gender gap in their schools, and so this study focuses on an analysis of individuals (mathematics

teachers) and then compares the results in order to begin to understand the gender gap.

Baxter and Jack (2008) use Yin's (2009) definition of multiple-case study to explain that,

A multiple case study enables the researcher to explore differences within and between cases. The goal is to replicate findings across cases. Because comparisons will be drawn, it is imperative that the cases are chosen carefully so that the researcher can predict similar results across cases, or can predict contrasting results based on a theory (p. 548)

Three perspectives inform the view of teaching and learning mathematics under investigation in this dissertation study: (1) Van de Walle's theory on teaching through problem solving (Van de Walle, 2001), which states that PSA means that students learn mathematics through real contexts, problems, situations, and models (2) formative assessment theory (Black & Wiliam, 2009; Wiliam, 2010) that says assessment should inform instructional decision making taken by either teachers, peers, or the learners themselves to improve student learning, and (3) social constructivism, whereby learning is a social activity that manifests in mathematics classroom discourse (Fosnot & Perry, 2005; Richardson, 2003). I was able to analyze the different teaching practices (using PSA and FA in secondary school mathematics classrooms) engaged in by mathematics teachers in each of the three secondary schools participating in this research. Stake (1995) calls such kind of work *collective case study* and not multiple-case study. I considered the three secondary schools in Tanzania that participated in this dissertation study to be multiple bounded systems.

## **Purposeful Sampling**

The schools were purposefully selected based on their performance in the Certificate of Secondary Education Examinations (CSEE), convenience, access, and geographic proximity to each other in an effort to place boundaries on the case. These schools are not very far from each other. From Mwanzoni to Bunge is 10 miles, from Mwanzoni to Kasheshe is 80 miles, and from Bunge to Kasheshe is 70 miles. Several authors have suggested ways to bind a case by time and place, by time and activity, and by definition and context (P. Baxter & Jack, 2008; Creswell, 1998; Miles & Huberman, 1994; Stake, 1995; Yin, 2009). According to Baxter and Jack (2008), “binding the case will ensure that your study remains reasonable in scope” (pp. 546-547).

I used purposeful sampling techniques to select the participants because purposeful sampling is an important process of the selection of cases in a qualitative study (Miles & Huberman, 1994). Purposeful sampling in case study research provides the researcher with the opportunity to select and learn from the most promising participants. Miles and Huberman (1994) state, “your choices—whom to look at or talk with, where, when, about what, and why—all place limits on the conclusions you can draw, and on how confident you and others feel about them” (p. 27). According to Merriam (1997), “purposeful sampling is based on the assumption that the investigator wants to discover, understand, and gain insight and therefore must select a sample from which the most can be learned” (p. 61). The three participating schools in this dissertation study also participated in my early research study (Zilimu, 2009).

### **Schools' performance in the CSEE.**

Mwanzoni and Kasheshe secondary schools are considered very high performing schools in the district; Bunge secondary school is a high-performing school. According to the Serve Africa website (2011), the rankings of secondary schools are based on school success in five categories: (1) academic challenge, (2) quality of faculty, (3) campus environment, (4) student performance, and (5) public perception. Teachers in different schools under different rankings might have different views about gender gap.

Table 5

#### *Ranking of the Three Schools in the CSEE 2011 Results in Tanzania*

Name of secondary school	Number of students passed	Number of students failed	Total number of students	Position out of 180 schools in the region	Position out of 3108 schools in the nation
Mwanzoni	74	0	74	6	79
Kasheshe	153	1	154	9	132
Bunge	72	62	134	59	1161

The National Examinations Council of Tanzania (NECTA) administers the CSEE to all senior students in October of each year. The secondary schools are in two groups: The first group is composed of the schools with fewer candidates than 40 and the second group has the schools with 40 candidates or more. Each group is subdivided into very high performing, high performing, medium performing, and low-performing subgroups. All three secondary schools belong to one group, which is composed of the centers with 40 candidates or more. Table 5 shows the three schools and their ranking in the northwestern region of Tanzania from the CSEE 2011 results. Comparing the three participating secondary schools in the northwestern region of Tanzania within the past

five years we see that Mwanzoni ranks number one, Kasheshe ranks number two, and Bunge ranks number three. From the district level, Mwanzoni and Kasheshe belong to very high-performing subgroup and Bunge belongs to the high-performing subgroup. However, on the national level, Mwanzoni and Kasheshe still belong to the very high-performing subgroup and Bunge belongs to the medium-performing subgroup.

Although all the three schools are high performing schools the findings of my early research (Zilimu, 2009) show there is a big difference in the gender achievement gaps (see Table 4). Since all the teachers help the schools to get to the high performing rank in their district, they are probably not bad teachers. The teachers had teaching experience of between 11-20 years. Something must have been happening in the classrooms, which leads to big gender achievement gaps. The three schools represent sites from which I expected to learn the most.

### **Teachers' Background Information**

Three mathematics teachers each from a different secondary school I visited in the northwestern region of Tanzania voluntarily agreed to participate in this study. The teachers had an average teaching experience of 15.67 years. Their mathematics teaching experience averaged 11.33 years, and form four mathematics teaching experience averaged 8.67 years. Mr. Isidor has a Bachelor of Science degree in geology, and both Mr. Leo and Mr. Patrick have a diploma in education.<sup>5</sup> Mr. Leo had the largest class (80 students).

Two of the three schools were private, and the third one was a government school. All the secondary schools were co-educational (the school population comprised boys

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<sup>5</sup> A diploma in education in Tanzania is obtained from teachers' training colleges not universities.

and girls). The number of students in each class at the three schools was: 74 students at Mwanzoni Secondary School (24 girls and 50 boys), 80 students at Kasheshe Secondary School (26 girls and 54 boys), and 79 students at Bunge Secondary School (37 girls and 42 boys). A total of 233 students (95 girls and 138 boys) participated in the study. Table 6 presents the background information of the three mathematics teachers and the composition of their classrooms.

Table 6

*Participants' Demographic Data in 2013*

SN	SPLNE	TN	TLE	TE	MTE	FMTE	NPS	
							Girls	Boys
Mwanzoni	Very High	Isidor	BS	20 years	9 years	8 years	24	50
Kasheshe	High	Leo	DE	16 years	16 years	10 years	26	54
Bunge	Middle	Patrick	DE	11 years	9 years	8 years	37	42

Key

SN: School name

SPLNE: School performance level on 2012 National Examination<sup>6</sup>

TN: Teacher name

TLE: Teacher's level of education (DE = diploma in education, BS = bachelor of science)

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<sup>6</sup> The government designates each school's level of performance for the nation.

TE: Teaching experience

MTE: Mathematics teaching experience

FMTE: Form four mathematics teaching experience

NPS: Number of participating students

The classrooms were all form four.<sup>7</sup> In general the number of girls across the three classes was smaller than the number of boys. I assume part of the reason is because all the schools are high performing schools in Tanzanian standard and not many girls are interested in applying to go to those schools because they think they may not be accepted and some of it is the culture. The point on the role of the culture will be expanded in the results chapter.

In this dissertation study I am interested in learning more about the gender achievement gap in secondary school mathematics in Tanzania from the teachers' perspectives and their instructional practices. The knowledge of the participants (three teachers) from working with them in my early research (pilot study) helped me gain a better understanding of the more regular patterns of behaviors in the teachers' instructional practices. Performing more observations of these teachers as they taught mathematics at different times of the day and interviewing them helped me to organize a write-up that contributes to the reader's understanding of the case.

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<sup>7</sup> Form four is equivalent to 12th grade in the United States

## **Data Collection**

Data collection occurred in the spring semester of 2013 after I received explicit permission from the participants. According to Creswell (2007) “an important step in the process [data collection] is to find people or places to study and to gain access to and establish rapport with participants so that they will provide good data” (p. 118). Since I already had established rapport with the participants, I anticipated that I would gather good data. All data gathered from participants were collected in full compliance with the Institutional Review Board (IRB) guidelines.

In accordance with the characteristics of qualitative research, the evidences for this case study came from multiple data sources, a strategy that also enhances data credibility (Merriam, 1997; Patton, 2002; Stake, 1995; Yin, 2009). The data sources for this case study were observations (see Appendix A) and interviews (see Appendix B). I adapted the observation protocol from Local Systemic Change—LSC—classroom observation protocol by Horizon Research, Inc. (Horizon Research, 2005), Oregon Mathematics Leadership Institute—OMLI—classroom observation protocol (Weaver, et al., 2005), and Reformed Teaching Observation Protocol—RTOP—(Piburn & Sawada, 2000). LSC, OMLI, and RTOP are the established classroom observation protocols that have been used to try and monitor reform-oriented teaching. I essentially merged the most relevant (for the purposes of this dissertation) parts of the LSC, OMLI, and RTOP. My focus was on the parts that emphasize diversity (gender related) information, teaching through problem solving, discourse and formative assessment. I took some relevant parts from each observation protocol and developed one observation protocol known as Sensitivity to Gender, Problem Solving and Formative Assessment in Mathematics—

SGPSFA (see Appendix A). LSC, OMLI, and RTOP observation protocols intended to be used by more than one observer and after classroom observations all observers met to discuss their observations with each other. However, according to the nature of dissertation study I was the only observer who used the protocol SGPSFA. I used SGPSFA observational instrument to collect the data, which I used to assess the Tanzanian teachers' understanding of their own teaching practices and their perspectives of gender gap in the teaching of mathematics. The instrument SGPSFA measured the following major concepts and descriptive information: School context, classroom context, teachers' background information, designing a lesson, implementing a lesson, respecting diversity, monitoring student learning, teaching through problem solving, questioning, answering, making a statement or sharing, justifying, listening, challenging, explaining, predicting or conjecturing, generalizing, and relating.

The National Council of Teachers of Mathematics (NCTM), set forth a vision for K-12 mathematics education reform. *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989), *Professional Standards for Teaching Mathematics* (NCTM, 1991), and *Assessment Standards for School Mathematics* (NCTM, 1995) explain that “mathematics reform” emphasizes written and verbal communications, working in cooperative groups, and making connections between concepts as opposed to the “traditional approach,” which emphasizes procedural mathematics and providing step-by-step examples with skill exercises. The PSA and FA frameworks and the standards documents guided the development of the SGPSFA observation protocol. The SGPSFA observation protocol has three sections. The first section is the background information. This information served to identify the school, the instructor, the date and time when the

lesson was observed, and the duration of the observation. Each school had two sections per class. If the teacher taught more than one section I asked him to select one so that I observe the same class section for each subsequent observation. We scheduled observations accordingly. The second section of the protocol is the contextual background and activities. In this section I recorded any relevant details about the students (number and gender) and the teacher that I thought was important. I also recorded the information that briefly describes the lesson observed (purpose of the lesson, lecture or discussion, classroom activities, etc.) and classroom setting in which the lesson took place (space, seating arrangements, etc.). The third section contains fifty-two items to be rated measuring the major concepts in Table 9. Each item was rated on a scale from 1 (Never) to 5 (Consistently). The exercise of rating the 52 items was done three times (after each of the three observations) hence a total of 156 rated items. Possible scores ranged from 156 to 780 points since  $1 \times 156 = 156$  and  $5 \times 156 = 780$ . I completed this section after observations. During observations I took notes while observing and immediately after the lesson, I drew upon my notes and completed the ratings.

I did three formal classroom observations from each teacher (three teachers), which totaled to nine formal classroom observations, and each observation was between 60 to 75 minutes long. Secondary school mathematics classes in Tanzania last 80 minutes. Part of my activity was to look for gender differences during classroom instructions. Before each observation I did a short pre-observation interview (see Appendix B). The aim of these pre-observation interviews was to gain information about the context of the lesson before it started. I used the same set of questions at all nine pre-observation interviews. During the pre-observation interviews I expressed appreciation to

the teachers for allowing the observation, and I answered any questions they had about confidentiality, the use of the data collected, the incentive, and so on. I also did a total of nine semi-structured interviews, and each interview was at least 45 minutes long. I took field notes during the interviews and classroom observations. Each semi-structured interview was preceded by classroom observation. The classroom observations and interviews were audio taped to allow the observer to take field notes.

After each classroom observation and before an interview I transcribed some parts of the audio taped materials, which helped me to ask productive follow-up questions during the interviews. Interviews and observations are commonly used in qualitative case study research (Denzin & Lincoln, 2011; Stake, 1995; Yin, 2009). Triangulation was sought among the multiple data sources. Denzin (1978) calls the use of more than one method to gather data a *methodological triangulation*. Mathematics teachers' interviews formed the primary source of the data, and classroom observations were used to guide, support or challenge the interviews.

Each teacher was interviewed three times on three different days, which makes a total of nine interviews. Semi-structured interviews provided for consistent investigation of particular topics/categories/themes with the participant and basic introductory questions, and also afforded flexibility to engage in natural conversation that provided deeper insight. I entered into interviews with the expectation that the interactions with the participants would establish a human-to-human relationship with the respondent and the desire to understand rather than to explain. Explaining semi-structured interviews, Fontana and Frey (1994) say that the semi-structured interview makes an interview more honest, morally sound, and reliable, because it treats the respondent as an equal, allows

him or her to express personal feelings, and therefore presents a more “realistic” picture than can be uncovered using traditional interview methods (p. 371).

While a structured interview has formalized, limited set questions, a semi-structured interview is flexible, allowing new questions to be brought up during the interview as a result of what the interviewee says. During the interviews handwritten notes were taken for the purpose of extending questions or to be used as my notes for further investigation. I conducted all the interviews on the secondary schools’ campuses and most of the interviews during school hours. However, I was unable to conduct three interviews with Mr. Patrick during school hours, so accommodations were made for his schedule, and the interviews were conducted after school hours. I performed the first observation during his morning class on Monday from 9:03 am to 10:15 am, which was preceded by a ten-minute pre-observation interview. I came back to Bunge Secondary School in the evening, and I interviewed him from 6:00 pm to 6:50 pm. The following day (Tuesday) I had an eight-minute pre-observation interview, which was followed by the second classroom observation in the afternoon from 2:02 pm to 3:10 pm. I came back on Wednesday evening at 5:15 pm and interviewed him for 46 minutes. I had the third classroom observation with him on a Thursday from 10:03 am to 11:08 am, which was preceded by a seven minutes pre-observation interview. Mr. Patrick was not available on Thursday evening, so I went back on Friday evening and interviewed him from 6:00 pm to 6:50 pm.

I spent one week at each school observing mathematics lessons at different times of the day and doing interviews. I observed as many lessons as each of the three teachers could teach one class section per week (3 lessons per class section) because I had only

one month to collect data in Tanzania and come back to the United States. I collected data under time constraints. However, I continued communicating with the teachers through emails and phone calls whenever I needed some more information during the data analysis and reporting stages.

Table 7 shows the lengths of the interviews and classroom observations in minutes for each teacher. However, none of the classroom observations covered the whole classroom period that is 80 minutes, because either the classes started later or there were some announcements, assigning homework and other activities, which were not related to the lessons. I did a short interview before each classroom observation.

Table 7

*The Length of Interviews and Observations in Minutes for Each Teacher*

Interviews and Observations	Mr. Isidor	Mr. Leo	Mr. Patrick
1st Pre-observation Interview	8	9	10
2nd Pre-observation Interview	8	9	8
3rd Pre-observation Interview	7	8	7
1st Interview	48	47	50
2nd Interview	50	47	46
3rd Interview	47	46	50
1st Observation	75	78	74
2nd Observation	72	73	70
3rd Observation	70	68	68

The protocol of data collection was: Pre-observation interview—Observation—Interview—Pre-observation interview—Observation—Interview—Pre-observation interview—Observation—Interview. The purpose of the first formal interview was to

better understand the teachers' teaching experiences and their understanding of the gender gap. Sample questions for this interview included the following:

1. How long have you been teaching? At . . . secondary school?
2. Have you always worked in schools with similar demographics as this one?
3. Have you ever worked with single-gender classes? If yes, what was your experience? Where were the differences between the groups, if any?
4. How would you compare the academic performance of male and female students?
5. Research shows that there is gender gap in secondary school mathematics achievement. Why do you think there is gender gap?

The second interview took place after the second classroom observation had taken place. The purpose of this interview was to understand the teachers' understanding of their teaching within a PSA framework. Sample questions for this interview included the following:

1. Most teachers would say that they want their students to understand mathematics. Are you one of them? If yes, how do you know that a student understands how to add 35 and 47? If no why not? (Teaching for understanding)
2. What do you normally do to facilitate conceptual understanding? (The role of the teacher)
3. Teachers who use a PSA believe that every student has the right to reflect on, and communicate about, mathematics. How do you give equitable opportunities for all students in your classroom? (Equity and accessibility).

4. How do your students interact about mathematics? (Social culture of the classroom).
  - a. How do you react to student's ideas/answer?
  - b. Do you give your students opportunities to share their answers with their peers?
  - c. How do you and your students see mistakes? What do you normally do when a student makes mistakes?
  - d. Are you surprised when a very weak student (a girl you know is weak in classroom) gives a persuasive explanation or correct solution? If yes, why and if no, why not?

The third interview took place on my last day at each of the school. The purpose of the interview was to understand the teachers' understanding of their teaching within a FA framework. I sought to know whether the teachers consciously integrated FA into a PSA. Sample questions for this interview included the following:

1. What have been your biggest challenges in teaching mathematics this year?
2. What ways do you typically use to identify your student strengths and areas of difficulties in math?
3. Do you use the mistakes your students make when they answer questions in class? If yes, how? If no, why not?
4. Looking back over this school year,
  - a. Do the national examination results help you reflect on your students' progress over the course of the entire year? If so, how? If not, why not?

- b. Has looking at the national examination results led you to rethink anything about the way you teach? In what ways?

The semi-structured interviews were audio taped and transcribed. The analyses of the data of each interviewee were made available for each to review for the purpose of member checking. Member checking is generally considered an important method for verifying and validating information observed or recorded and transcribed by the researcher (Merriam, 1997; Stake, 1995). According to Stake (1995), in a process called member checking, the actors [participants] “help to triangulate the researcher’s observations and interpretations” (p. 115). I used emails to communicate with the teachers after I came back from the field. They had the opportunities to write back and give their comments about my analyses, interpretations, and conclusions. All the teachers liked what I asked them to member check. For instance, Mr. Isidor said that “we need people like you from outside to come to our schools, observe and interview us . . . your interpretations help us to know how we are doing and so we can correct our teaching approaches . . .” The other two teachers, Mr. Leo and Mr. Patrick, did not give comments other than saying they were satisfied with my interpretations.

Observation is the second data source of this case study research. I only conducted direct observations. I made all efforts to be as unobtrusive as possible during the lessons. I avoided three things during classroom observations: First, I avoided distracting the students and teachers by staying out of the spotlight as much as possible. Second, I avoided interacting with the students in a way that took their attention away from the lesson, and third, I avoided the urge to help the students with the activities or assignments. Direct observations provided me with ways to record how much time was

spent on various activities. I also used the classroom observation time to make notes, which I used to complete section three of the observation protocol. I did intentional interactions with teachers and students, either before or after classroom observations, to bridge the gap between the observer and the participants. Intentional interactions helped me become more familiar to the teachers and students, thereby easing facilitation of the research process.

Similar to the interviews, all observations were conducted carefully with strict consideration for the research participants. I observed the teachers teaching mathematics while paying attention to the way the teachers asked questions and responded to the students' answers. I selected the least obtrusive location in the classroom from which I could operate. I took notes on the actions of the teachers, their interactions with students, and lesson implementation. I checked for nonverbal expression of feelings, determined who interacts with whom, and grasped how teachers communicated with students and how students communicated with each other. The data from interviews, field notes, and observations were the sources for data analysis.

### **Data Analysis**

According to Creswell (2007), "data analysis in qualitative research consists of preparing and organizing the data (i.e., text data as in transcripts, or image data as in photographs) for analysis, then reducing the data into themes through a process of coding and condensing the codes, and finally representing the data in figures, tables, or a discussion" (p. 148). In agreement with the nature of qualitative case study research, I conducted the preliminary data analysis simultaneously with data collection (Patton, 2002; Stake, 1995; Yin, 2009). The analysis and interpretation of the data processes were

guided by the two research questions I wanted to answer. The data gathering and analysis was an important phase for developing a clear understanding of the achievement gender gap in Tanzanian secondary school mathematics.

Table 8

*Categorizing Information for the Interview Data*

<b>Code</b>	<b>Explanation</b>
Instructional Practices—IP	The teacher acknowledges that teaching practices might cause gender gap
Content Knowledge—CK	The teacher acknowledges that content knowledge is very important to help students learn mathematics
Stereotype—S	The teacher believes that girls are not good at mathematics and science.
Gender Bias—GB	The teacher conveys girls that they are unequal to boys For instance: Seating or lining up students by gender.
Culture—C	The teacher believes that culture contributes to the existence of gender gap by making girls loose self-confidence in mathematics
Student Participation—SP	The teacher conveys that each student is responsible for his/her own learning. All students should participate actively in classroom discussions.
Teacher Approach—TA	The teacher conveys students that he cares about their learning.
Big Classes—BC	The teacher acknowledges that overcrowded classrooms affect negatively student learning.
Ignoring Diversity—ID	The teacher does the minimum or nothing to help low achievers.
Benefits to Students—BS	The teacher believes that PSA and FA give students many opportunities such as self-assessment, peer-assessment, equity and accessibility, ability to use mathematics tools, and friendly interactions.
Benefits to Teacher—BT	The teacher believes that the information about student leaning gathered from discussions helps him to improve his teaching.
Use of Questions—UQ	Questions are used to practice the formulae the teacher taught. The teacher uses questions from books and no applications to the real world

*Note: Code abbreviations in Table 8 are designated after the codes.*

From a large, multi-site study Huberman and Miles (1983) outlined a detailed procedure for data gathering and analysis from which I borrowed five procedures to conduct my own analysis.

First I used the “coding” procedure to organize and theme the data (See Tables 8, 9 and 10). The process of creating codes was both pre-set and open (emergent). The pre-set codes derived from the conceptual framework, the two research questions and the classroom observation protocol (Appendix C). I applied the protocol developed in appendix C to the observation data. I listened to the recordings (observations and interviews) several times and I also read and re-read the transcripts and field notes to understand and analyze the data. I wrote down any ideas, concepts, phrases, actions, meanings, and impressions that came up as I went through the data. I kept only the codes that emerged and were different than the pre-set codes. I organized the emergent codes into coherent categories. Table 8 presents the actual codes I came up with. I assigned abbreviated codes of a few letters and placed them next to the themes and ideas I found. The codes in Table 8 derived from interview data and field notes.

Secondly, I used the “dictating field notes” procedure to write down what I saw and heard as opposed to verbatim recordings. Thirdly, I used “Connoisseurship” (researcher knowledge of issues and context of the site). I applied the knowledge of achievement gender gap in Tanzanian secondary school mathematics that I got from doing early research to further explore the nature of gender gap. Fourthly, I used “progressive focusing and funneling” (winnowing data and investigative technique as study progresses). I started analyzing the data during data collection stage. The analysis

process continued as the study progressed until I finished the writing stage. Finally I used the “Outlining” procedure (standardized writing formats).

The observation data were used to compare the instructional practices of the participants. I applied the preset codes in Appendix C to the data I collected in section three of the classroom observation protocol (see Appendix A). The first column of Table 9 shows the preset codes and their abbreviations and the second column contains the items in section three of the observation protocol to which the codes were applied.

Table 9

*Codes and the Observation Items to which the Codes were Applied*

<b>Codes</b>	<b>Items</b>
Designing a lesson—DL	A: 1 to 5
Implementing a lesson—IL	A: 7 to 13, 15
Respecting Diversity—RD	A: 16
Monitoring student learning—MSL	A: 17, 18, 23, and D: 1 to 11
Teaching through problem solving—TPS	A: 19 to 22 and C: 1 to 5
Questioning—Q	B: 1
Answering—A	B: 2
Making a statement or sharing—MS	B: 3
Justifying—J	B: 4, 10
Listening—L	B: 5
Challenging—C	B: 6
Explaining—E	B: 7, 11, and 12
Predicting or conjecturing—P	A: 6 and B: 8
Generalizing—G	B: 9
Relating—R	A: 14, C: 6

I used the preset codes/themes to create a word table to display the data from the three mathematics teachers according to the PSA and FA frameworks (see Table 10). The word table I used is a seven-column table to compare the teachers in terms of the themes. All the codes fitted the observation data, the results, which provided me with a direction for what I was looking for in the observation data. The use of a word table helped me look for similarities and differences in the teachers' teaching practices (Creswell, 2007; Yin, 2009). In the cells adjacent to a code and under each teacher, a score was marked to indicate the total score the teacher received.

Table 10

*Comparing the Teachers*

<b>Code</b>	Number of items	Minimum score	Maximum score	Mr. Isidor	Mr. Leo	Mr. Patrick
Designing a lesson—DL	5	15	75	52	41	40
Implementing a lesson—IL	8	24	120	73	67	64
Respecting Diversity—RD	1	3	15	8	7	6
Monitoring student learning—MSL	14	52	210	93	82	82
<b>TOTAL</b>	<b>28</b>	<b>84</b>	<b>420</b>	<b>226</b>	<b>197</b>	<b>192</b>

I rated each of the items three times (three observations). Each teacher received a minimum score of 1 and a maximum score of 5 each time the items were rated.

The formula for calculating the minimum score for each code is: Number of items x 3 x 1 and the formula for calculating the maximum score for each code is: Number of items x 3 x 5. For instance the minimum score each teacher got for the code, “Designing a lesson,” was  $5 \times 3 \times 1 = 15$  and the maximum score was  $5 \times 3 \times 5 = 75$ . The information obtained

was helpful in a more extensive data analysis. A complete word table is in Chapter IV (see Table 14).

The simultaneous data collection and data analysis procedures allowed me to organize the transcribed interviews and field notes into summaries that helped in the further analysis of the data. The further data analysis involved the generation of meaning from the interview transcripts and observation field notes. The data analysis proceeded from noting patterns and themes to arriving at comparisons and contrasts of the teachers' teaching practices to determining explanations of mathematics gender gap in Tanzanian secondary schools.

The following chapter is the reports and interpretations of the data I collected from Tanzanian secondary school mathematics teachers.

## Chapter IV

### Results

In this chapter I report on an empirical study of three Tanzanian secondary school mathematics teachers' understandings of their own teaching, their understandings of problem solving approach (PSA), formative assessment (FA), their classroom contexts, and the gender gaps in mathematics achievement. In this dissertation study, I sought to understand the nature of teachers' instructional practices, and to explore the relationships between the teachers' understanding of PSA and FA and how they understand gender gaps in mathematics achievement in the context of their instruction. This chapter is divided into two sections. The first section covers the Tanzanian teachers' understanding of PSA and FA in the context of their mathematics teaching. The second section explores ways in which the teachers' instructional practices might perpetuate the gender gaps in mathematics achievement.

#### **PSA and FA in the Teachers' Understanding of their Teaching Practices**

In this section I concentrate on answering the first research question of this dissertation, which is: "How do Tanzanian secondary school mathematics teachers' understandings of their own teaching reflect PSA and FA practices in the context of their instructional practices?" I analyze and report on the interview data as I discuss the teachers' use of PSA and FA in mathematics teaching. However, I also report on some observation data, which either support or contradict what the participants said in the interviews.

The need for mathematics in a changing world has been the central theme for a long time throughout the world. All students should have the opportunity and the support

necessary to learn significant mathematics with depth and understanding. Secada and Berman (1999) explain that equity is a value-added dimension in the teaching mathematics for understanding. PSA and FA practices require a teacher to help all students to develop confidence that they have the ability to learn mathematics (Black & Wiliam, 2009; Harlen, 2006; Hiebert, et al., 1997). The teachers need to tell the students that they believe their students can do mathematics. PSA allows multiple paths to the solution. The teacher should encourage the students to use their own mathematical ideas to solve a mathematics problem. In FA practices, the teachers regularly check the students' understanding during their instructional practices (Popham, 2008; Wiliam, 2008), and then use evidence of students' mathematical understanding, along with other evidences from the instructional process, to modify instruction. FA practices facilitate students' learning (Black & Wiliam, 1998a). Instructional features such as classroom discussions, giving constructive feedback, creating meaningful and engaging contexts, and allowing multiple paths to the solution enhance PSA and FA practices.

### **The teachers' instructional practices.**

One of the features of a PSA is to let students do the talking. The teacher should prepare the students to participate actively in the whole class discussion, which occurs after working on a problem either individually or in small groups. Classroom discussions in FA practices are used as assessment conversations (Ruiz-Primo & Furtak, 2006). In chapter three of this dissertation I discussed how Ruiz-Primo and Furtak (2006) concluded that the teacher-student interaction in classroom assessment that was consistent with ESRU cycle model (teacher asks a question to Elicit student thinking,

Student responds, teacher Recognizes the student's response, and the teacher Uses the information collected to support student learning) improves student achievement.

However, the observations of classroom discussions in this dissertation study were guided by Mehan's (1979) social structure of classroom lessons. According to Mehan (1979) the social structuring of classroom lessons indicates a robust pattern of interaction known as IRE (initiation, reply, and evaluation). IRE is sometimes referred to as IRF (initiation, reply, and feedback) (Cazden & Beck, 2003). A teacher asks a question (initiation), one or more students answer (reply), and the teacher comments on the students' answer (evaluates or gives a feedback). This three-part sequence can be extended when a teacher (or student) prompts, hints, repeats elicitations, or simplifies initiations. In all the three classrooms the teacher-student interactions did not go further than IR (initiation and reply) pattern. The participants' responses to the interview questions revealed that most of the time the social structure of their classrooms started with initiation and ended with reply (IR) partly because they wanted to keep the discussions moving forward.

It was rare that the teacher either evaluated or gave feedback. PSA and FA are instructional practices, which give students opportunities to share their strategies with their peers during classroom discussions. The teacher, in turn, understands the students' mathematical thinking and then he or she uses the assessment information to make instructional decisions (Van de Walle, et al., 2010). The use of PSA and FA practices entails the teacher using the learning evidence to modify the instructions in order to help student learning. It was clear from the interviews with the teachers that the large class size could not allow them to give each student enough time to talk. All the teachers

argued that there is no way they could finish the national mathematics curriculum if they would not keep things moving.

In mathematics education, discussions promote both confidence and a community in which students learn to value learning from other students (Hiebert, et al., 1996; Schleppenbach, Perry, Sims, Miller, & Fang, 2007). When I asked the teachers about their students' interactions with mathematics. Mr. Isidor, Mr. Leo and Mr. Patrick had similar responses. They said that they conduct whole class discussions, because it is hard for them to move around and help either individual students or students in small groups because of the big number of students.

The goal of PSA and FA is to improve students' learning and performance. This goal places students (the learners) in the central role of instructional practices in classrooms (Brookhart, 2001; Empson, 2003). Empson (2003) explains that we can expect the low-achieving students to participate fully in and benefit from mathematics discussion if the teachers show students that they value their mathematical thinking. All the three teachers who participated in this dissertation study said that they normally try to involve boys and girls in classroom discussions. However, their explanations of their instructional practices showed that they usually asked short answer questions (low-level thinking questions); for instance, "what is 2 plus 3" and they expected students to say "5" and move on. Short answer questions do not give students time to share their mathematics strategies unless the teacher prompts to check the students' understanding, but I did not see such a thing happening in the classrooms I observed. The teachers admitted that they used lower-level thinking statements and questions because they wanted to get correct answers from the students and move along. There was no way they

could give all students an opportunity to express their mathematical thinking since the number of students in their classes was too big. None of the teachers used higher-level thinking statements and questions to a great extent. Airasian (2005) explains that higher-level thinking questions increase the effectiveness of oral communications. Effective oral questioning is characterized by active participation of all students in classroom discussions.

Mr. Isidor and Mr. Patrick explained that whenever they ask a question and a student gives a wrong answer or does not answer at all, they keep asking the same question to different students until the correct answer is given. They both said they always ask short answer questions to check their students' mathematical understanding. All the teachers just asked students to provide procedures or algorithms or memorized rules. For instance, when Mr. Patrick was teaching how to calculate the mean of the data (Statistics), he asked a girl to tell everybody the first thing to be done in order to calculate the mean. She spoke but her voice was very quiet and the teacher as well as the students did not seem to pay attention to what she said. Mr. Patrick switched and asked a boy, who started explaining how to do it, then Mr. Patrick intervened and said, “. . . the procedure please.” Mr. Isidor said that he likes to ask students short-answer questions during classroom discussions because the students get opportunities to memorize the formulas. I noticed that more boys than girls were engaged in classroom discussions as evidenced in the following episode.

**Mr. Isidor:** What is twenty squared?

**Student 1 (Boy):** Four hundred.

**Mr. Isidor:** It is equal to four hundred, excellent! (He writes  $400 +$  on the board.) And what is sixteen squared? Yes (He points to a student with his hand up.)

**Student 2** (Boy): Two fifty six

**Mr. Isidor:** Two fifty six (He writes it on the board to complete the equation.) Then we add them up. What is four hundred plus two hundred and fifty six? Yes (He asks a girl)

**Student 3** (Girl): (She does not answer)

**Mr. Isidor:** Yes, (He asks a boy)

**Student 4:** It is equal to six hundred and fifty six.

**Mr. Isidor:** Very good!

Mr. Leo was unique in his instruction practices because he is the only teacher who used small group discussions in one of his three lessons I observed. From informal conversations I had with Mr. Leo, I learned that he conducts lectures in which he just teaches mathematics formulas and algorithms. Mr. Leo solves some mathematics questions from the books by himself while students take notes. During his lectures there are no discussions, but students are allowed to ask questions and he responds to the students' questions. The only time he holds some short classroom discussions is when he answers students' questions. In one of his three lessons I observed, he asked students to form groups of no more than five students and no less than two students and then he gave them questions to discuss in groups. Meanwhile he was moving around in class helping individual groups that had questions. "I will write questions on the blackboard and just discuss them in groups. If you get stuck somewhere just raise up your hands and I will come there to help you and look at your problems" (Mr. Leo's instructions at the beginning of the lesson I observed on February 18, 2013 at 9:02 a.m). However, he did

not ask any of the students from their small groups to share their mathematical strategies with the whole class. From the data I collected I hypothesize that Mr. Leo did not give opportunities to students to share their individual strategies to other students partly because of time constraint he worked under. Teachers in Tanzania work to finish the syllabus given by the National Examinations Council of Tanzania (NECTA), which is very long.

The key feature of FA incorporated in a PSA is that the students get opportunities to verify and relate their strategies. PSA provides ongoing assessment data useful for making instructional decisions, and helping students succeed (Hiebert, et al., 1997; Nathan, Eilam, & Kim, 2007; Nathan & Knuth, 2003). Nowhere in my study did I see clear evidence of the teachers in classrooms giving opportunities to students to share their mathematical thinking so that the rest could learn from their fellow students. I noticed that the teachers did not give the students enough time to talk, which is another important feature of PSA and FA practices. All the teachers said that if no student gets the correct answer, then they give the answer themselves. I was curious to know why they did not give students enough time to think about their answers. They all said they needed to keep moving on in order to finish the syllabus, which is given to them by the National Examinations Council of Tanzania (NECTA). Mr. Patrick added, “As a teacher I know the answer, so if I ask about three or four students and nobody gives the answer, I do it to help them and continue with another question.”

PSA and FA will aid learning through teacher-student interactions if teachers wait long enough to allow students to think out their answers (Black & Wiliam, 1998a, 1998b, 2006; Van de Walle, Karp, & Bay-Williams, 2007). Of the three teachers, Mr. Isidor

sometimes waited before he called on a different student, but not long enough. The waiting time was shorter when he asked girls than when he asked boys. When Mr. Isidor and I were discussing the issues of equity and accessibility he admitted, “Considering the big number of students in our classrooms, it is very hard to give equal opportunities to all students.” When I asked him to tell me the reason he waited longer when he asked boys than when he asked girls he replied, “You see, I know my students, I know who are strong and who are weak; if I ask strong students I expect a good answer, so I wait knowing something good will come out.” Mr. Patrick never waited at all. He either answered his own questions or asked another student after a few seconds.

Mr. Leo, who used small group discussions once, did not select the groups. He asked students to form groups of no more than five students and no less than two students. Once the groups were formed, he again asked each group to distribute roles among the members. The roles included group leader and recorder. Mr. Leo gave them questions to discuss in groups. Those who were selected for the roles in their individual groups kept their roles until the end of the lesson. Group work did not give everyone an opportunity to participate. In the groups that had boys and girls as members of the groups, only boys were assigned roles. The role assignments did not allow for girls to participate actively within the group and they seemed left out. Students formed the groups based on friendships, and that is why most of the groups were single gender and very few groups were composed of boys and girls. The group discussions did not provide opportunities for students to be able to interact with different individuals in the class. There was no whole classroom discussion after students had spent some minutes in small group discussions. According to Van de Walle’s three part structure of mathematics

lesson (Van de Walle, 2001), small group discussions should be followed by the whole class discussions in which students share with the whole class the strategies they used in small groups.

Exploring student understanding of concepts using questions is one of the characteristics of PSA and FA. Literature reveals that teaching through problem solving (Van de Walle, et al., 2007) and formative assessment practices (Black, Harrison, Lee, Marshall, & Wiliam, 2004; Black & Wiliam, 1998a) are very powerful tools to improve student learning.

### **Teaching for understanding.**

The primary goal of a PSA is making sense of mathematics (Hiebert, et al., 1997). The purpose of the problems or tasks is to explore, develop, and apply understanding of a mathematical concept (Hiebert & Wearne, 1993). The primary goal of FA practices is to frequently monitor students' understandings and problem-solving abilities so that the teachers can use the students' learning evidences to make instructional decisions. I noticed that all three teachers could not differentiate between learning computational skills and developing conceptual understanding. When I asked the teachers to tell me how they know that a student understands how to add 35 and 47, they had the following responses: Mr. Isidor said that "If I ask a student to give an answer to this question 35 plus 47 and says that it is 82, then it is proof that this student understands." Mr. Patrick said that "If a student tells me that he or she adds 5 and 7 first and writes 2 then carry the 1 and adds 1, 3 and 4 to get 8 hence 82, then the student understands what he or she is doing." When answering the same question, Mr. Leo said that "I just tell them to follow the procedures, the algorithms I taught them. If a student gives a correct answer, then I

know that the student understood what I taught them.” When grading students’ homework, he explained, “I normally look at the arrangements of the numbers . . . in ones or tens . . . I see if the numbers to be added line up properly . . . that is what I teach them before I give them homework. If the total is correct then I am satisfied.” The teachers seemed not to understand the difference between “understanding a procedure” and carrying it out. My next interview question after the above teachers’ responses was “Learning computational skills and developing conceptual understanding are frequently seen as competing objectives; in other words if you emphasize understanding, then skills suffer. If you focus on developing skills, then understanding suffers. Do you agree with this analysis? If yes, why and if no why not? All three teachers had the same first reaction to this question. They all asked to me to explain to them what I meant by “conceptual understanding.” Nobody asked me to explain what I meant by “computational skills” and I assumed that they all understood it. I concluded from the above teachers’ responses to the two interview questions that the teachers did not understand the difference between computational skills and conceptual understanding. For member checking purposes I shared my interpretation with them through email. They replied as follows:

**Mr. Isidor:** Yes, you are right father. I don’t know the difference . . . I can’t define conceptual understanding, how can I know how it differs from the other one [computational skills]?”

**Mr. Leo:** Your interpretations are correct.

**Mr. Patrick:** I agree with your conclusion because you remember I asked you to define “conceptual understanding” for me.

In order to address the teachers' PSA and FA practices I asked the teachers to share with me the approaches they use to assess students' mathematical understanding. I learned that the teachers had some differences and similarities in the ways they taught. All three teachers said that they liked whole class discussions. However, Mr. Leo said he also used small group discussions. Whereas Mr. Isidor and Mr. Leo spent some minutes of the lesson during the discussion and lecture in order to make problems clearer to the students, Mr. Patrick took very little time to lecture in his instructional style because he said, "I like it when the students say what they know." Before Mr. Isidor initiated the questions he first went through basic definitions and terms to be used in the discussion. Mr. Isidor's approach at this point is in line with what Van de Walle (2001) explains in the before phase of the three-phase lesson format of PSA (teaching through problem solving).

#### **Nature of classroom tasks.**

All the three teachers used questions from the books recommended by the NECTA, a section of the Ministry of Education in Tanzania. They used the questions, which had ready-made answers. When I asked the teachers about the approaches they used to implement their lesson plans, each gave explanations, which showed that they relied mostly on the books recommended by the NECTA. I specifically asked the teachers to explain the kind of mathematics tasks they give their students. I expected them to tell about the use of real-world problems in the teaching of mathematics. However, no teacher talked about the nature of classroom tasks to be used in a mathematics lesson that uses a PSA. I asked probing questions to help the teachers say what they know about the nature of classroom tasks to be utilized when a PSA and FA

are the instructional interventions to be used in teaching. They continued explaining where they get mathematics questions to ask students. I learned that if the teachers used real-world problems at all in their lessons, it was not intentional. Mr. Isidor said that, “I believe in giving students exercises, a lot of exercises, giving them as many exercises as possible, and actually I am normally impressed by the text-books we get from the Ministry; the Institute of Education.”

Mr. Patrick explained that, “I use books by the NECTA, from sponsors, donors . . . to teach mathematics because those books have good mathematics problems, which students can use to practice.” He continued to explain how he also uses other teachers’ pamphlets, which have questions and answers. He buys those pamphlets with questions and answers from the NECTA; he solves them first to make sure that he knows and understands how to solve the questions before he gives them to the students. Mr. Patrick commented that, “Sometimes I find that the method they used to do a certain question is very good. But sometimes you can find that here they used a method which is very complicated for the students to understand.” In this situation he looks for the easiest ways to solve the question and then he teaches the students simple ways to solve mathematics problems.

Table 11

*Typical Schedule for the Eighty Minutes Lesson*

Names of the teachers	RH	LT	IW	GW	CD	QA	AH	NO	Total minutes
Mr. Isidor	4	20	10	0	28	4	6	8	80
Mr. Leo	3	27	10	20	5	3	5	7	80
Mr. Patrick	2	21	18	0	24	6	0	9	80

## Key

RH: Review homework

LT: Lectures

IW: Students work on problems individually in class

GW: Students work on problems in groups (Group work)

CD: Class discussions

QA: Questions and answers

AH: Assigning homework

NO: Not observed

Table 11 is a typical schedule for the eighty minutes lesson for each teacher. I averaged times across the three observations per teacher to come up with the numbers of the minutes in Table 11. Mr. Patrick's approach in teaching mathematics is to tell students what to do and how to do it, and then he gives them questions to practice the mathematics formulas he teaches them during the lecture. All three teachers used almost similar approaches in which they taught mathematical formulas and then they gave students some questions to practice the formulas. However, Mr. Patrick differed from Mr. Isidor and Mr. Leo in the sense that he never took time to explain the questions he gave to his students so they knew what they were expected to do.

Low achievers will benefit from PSA and FA if the teachers concentrate on specific problems and explain the problems to students so that they get a clear understanding of what is wrong and how to put it right (Black & Wiliam, 1998a; Van de Walle, et al., 2010). Mr. Isidor and Mr. Leo gave some explanations and clarifications of the mathematics problems before they gave them to their students. Mr. Patrick, after

writing the question on the board, started leading discussions right away and left some questions for his students as homework.

### **Mathematics tools as learning supports.**

A problem solving approach to mathematics requires the use of mathematical tools such as oral language (problem posing), physical materials, written symbols, and skills students already have acquired (Hiebert, et al., 1997). All three teachers mentioned rulers, calculators, books, and mathematical sets as the common physical materials that they use to teach mathematics. Only Mr. Leo mentioned students as his number one physical tools. Mr. Isidor used drawings of the objects such as boxes, which they used in the mathematics discussions to communicate what he expected his students to solve. The use of the drawings was not successful. Students who were willing to ask for help asked questions, which showed clearly that they were having a hard time understanding three-dimensional figures on a two-dimensional plane. In my interviews with Mr. Isidor, he explained that the thought behind the use of the drawings was to give the students something they could use to visually see the relationships between the edges of the objects they were using to develop trigonometrical ratios. The follow-up interview with Mr. Isidor showed that the use of drawings in these particular lessons caused more confusion to students, especially girls. When the girls seemed confused, Mr. Isidor engaged only boys to keep the discussion going. Look at the following discussion:

**Mr. Isidor:** But then the question . . . we are not interested in AC as such. We are interested in AG. So, Eeem, again we can see here that there is a right-angled triangle on this corner up there. At that corner (He takes a blackboard ruler and draws AG.)

**Mr. Isidor:** (Takes the real box to show the side the whole class is interested in).

There is, there is a right angle, from here up to there and then you go upwards, up to G. There is a right angle there. This is the right angle. So we are having an angled triangle, which is ACG. ACG (He poses and repeats) ACG, It is a right-angled triangle. Now again we are going to use Pythagoras Theorem to be able to know the length of AG. Now what do you think is the length of AG according to the Pythagoras theorem? Sabrina (he asks a girl), the length of AG (He looks at Sabrina and waits for her to answer.)

**Mr. Isidor:** What is the length of AG? (He asks the question again.) From here to here. (He shows the side on the figure of a rectangular prism. Sabrina looks confused.)

**Sabrina:** (She does not answer.)

**Mr. Isidor:** (Waits a little more.) Yes, (Now he asks a male student.)

**Boy 1:** The length of AG is AC squared plus AG squared is equal to AG.

**Mr. Isidor:** (He looks not satisfied by this student's answer; he looks around).

Yes, (he asks another male student.)

**Boy 2:** The length of AG will be equal to AC squared plus CG squared, which is equal to AG squared.

**Mr. Isidor:** So (he writes on the board) AG squared is equal to AC squared plus CG squared. Now we are interested in this one (He points to AG squared.) So we can write AG squared is equal to AC squared; AC squared is this one here (he points to 656 and copies it down in the equation). Six hundred and fifty six plus CG squared, which is 12 squared.

**Mr. Isidor:** Twelve squared. (He looks around.) What is 12 squared?

**Students:** One hundred forty four.

**Mr. Isidor:** (He writes 144 on the board), When you add them up then, what do you get?

**Boy 3:** Eight hundred

**Mr. Isidor:** Eight hundred, very good. (He writes 800 on the board.)

### **The role of the teacher.**

Black and Wiliam (1998a) well noted that FA practices require a teacher to continuously gather evidence about learning and use the information from FA to adapt teaching and learning for the benefit of student learning. FA is only effective when teachers are clear about the intended learning goals for a lesson. Teachers who do not incorporate FA in their teaching insist more on ‘what are the students going to do?’ than ‘what are the students going to learn?’ In other words, the teachers insist more on the regulation of activity than on the regulation of learning (Stiggins, et al., 2006). Focusing on what students will learn, as opposed to what they will do helps the teachers determine the type of FA tasks and questions to ask students that will lead to learning.

In a reform-based mathematics instruction, teachers who incorporate FA into a PSA are instructed not to tell students but to guide and encourage the students to use their own strategies to solve problems. Teacher’s role is very important in classroom discussions because the teacher should control the amount of time used on discussing a certain mathematical concept, he/she should guide students at the times when they go off the intended mathematical concepts to be learned. Teachers have to ask students to explain their ideas and strategies and try to understand how the students perceive the

problem situation (Chazan & Ball, 1999). Teachers should not allow classroom discussions become arguments that will flash out of control. Baxter, Woodward, and Olson (2001) explain that in the whole class discussion only students who speak and listen get opportunities to ask questions, compare their answers with their peers and hence learn mathematics.

All the three teachers showed that when they teach mathematics they use the questions from either the books or from past national examinations. All the teachers showed that they like the questions because the questions help them to determine the focus and direction of the lesson. When I asked the teachers to explain the role of the students in preparing lessons they all said that students are learners and they have nothing to do with lesson planning. All the teachers did not share the learning goals with their students. During my collecting data process I was unable to tell the teachers' procedures on how they gathered students' evidence of emergent learning. Mathematics reform suggests that the focus and direction of the lesson should be determined by the ideas originating with students (Stiggins, et al., 2006; Van de Walle, et al., 2010).

Through observing the three teachers' classroom instructions, I noticed that in all three classrooms teachers did not seem to encourage all students to actively participate in discussions. However, during the interviews they all said that they encourage all students to become mathematically powerful and to take charge of their learning. Encouraging students to interact and present their mathematical ideas with their peers by telling them to do so is not enough in itself. The teachers should make sure that the students have confidence and trust in them. Students' confidence in mathematics and their trust in the teacher are very important elements in making classroom discussions mathematically

purposeful and fruitful (Huebner, 2009; Wood, 1994). All the teachers said that some of their students (especially girls) did not have confidence in mathematics, but none of the teachers was able to give strategies that can help the students gain confidence. When I asked them to explain what everyone does to help students learn mathematics, Mr. Isidor said, “I give them a lot of questions to practice.” Mr. Patrick had a similar idea to Mr. Isidor’s. However, Mr. Leo’s answer was different. He said, “I want to be present for the students and to listen carefully to their needs.” However, all the teachers gave the questions to the students and they had specific formulas, which they expected their students to use. According to Hiebert and his colleagues (1997) teachers should make mathematics problematic by engaging students in meaningful tasks that leave residue, and by encouraging student reflection and communication. The teachers also should create a classroom environment that helps students feel that they are able to solve mathematics problems. Students need words of encouragement to be followed by actions.

### **Creating meaningful and engaging contexts.**

For more than 30 years the education system in Tanzania under the NECTA has made mathematics a mandatory subject for all students in junior secondary school. According to the Ministry of Education in Tanzania, the provision of education is a basic human right and quality education for all Tanzanians is the government’s goal (Tanzania National website, 2001); however, girls are still left behind (Sutherland-Addy, 2008; Zilimu, 2009). To help all students learn mathematics a teacher should create a context that is familiar to the students by providing real-world problems (Van de Walle, et al., 2010). In their articles on FA, Paul Black and Dylan Wiliam give a scheme that tells us what the teacher should do. It overlaps with PSA. Black and Wiliam (1998a) argue that

the teacher in a classroom that uses formative assessments must give up some control and encourage students to participate in developing learning goals and outcomes. In an article explaining the importance of using formative assessments in the classroom, Black and Wiliam (1998b) make several suggestions for effective implementation of formative assessments: (1) teachers should pay close attention to the nature, contextualization, and timing of FA, (2) FA should not include too many recall or rote activities, (3) teachers involved in FA models should not emphasize grading over learning, (4) in the FA model, there should be more of a cooperative and less of a competitive classroom atmosphere, (5) teachers must focus on quality rather than quantity, (6) feedback in FA model should be focused on the task, not the student, (7) teachers should provide opportunities for students to express their understanding. Black and Wiliam (1998b) argue that if formative assessments are implemented incorrectly, they can have negative outcomes. They also argue that if formative assessments are paired with a more summative model of assessment, they can be ineffective.

I noticed that although the teachers had no intention to keep girls behind and would actually like to see girls do better in mathematics, their understanding of teaching and learning probably influenced the ways they treated girls in classes.

### **Perpetuating Gender Gap in Tanzanian Secondary School Mathematics**

In this section I concentrate on answering the second research question of this dissertation study, which is “How do the Tanzanian secondary school mathematics teachers’ perceptions of their teaching practices and their classroom contexts perpetuate gender gap?” I analyzed and reported on the observation data and some interview data to answer this question. Throughout the four weeks of data collection, I interviewed

teachers and did classroom observations. Various instances of gender inequity were noticed. I continued communicating with the participants via emails and phone calls during the analysis and writing process of this dissertation study. I shared with the participants my analysis, interpretations and conclusions for the purpose of member checking. In this section I discuss the conditions that may explain gender inequity in Tanzanian secondary school mathematics classrooms in two subsections: The first section is on mathematics teaching and gender inequity. In this section I explain the contextual constraints such as school factors, classroom factors, and culture the teachers are working under and how they contribution towards gender inequity in Tanzanian secondary schools. The second section is on the teacher actions and beliefs about gender inequity in mathematics achievement. In this section I discuss gender bias that is endemic in the Tanzanian society at large.

### **Mathematics teaching and gender inequity.**

The findings in my early research (Zilimu, 2009) show that gender gap in mathematics achievement still exists in Tanzanian secondary school classrooms. The gender gap widened in classes in which boys were openly favored. From what I observed, the conditions that might explain the gender inequity relate to schools, classrooms, or culture.

#### ***School factors.***

The three school populations (see Table 12) are considered to be large by Tanzanian standards. However, the number of girls across the schools is smaller than the number of boys. The percentages of girls at the three secondary schools were as follows:

At Mwanzoni Secondary School the girls were 40 percent, at Kasheshe Secondary School they were 42.5 percent, and at Bunge Secondary School the girls were 46.8 percent.

Table 12

*Number of Students at the Schools*

Name of school	Number of girls	Number of boys	Total
Mwanzoni	240	360	600
Kasheshe	340	460	800
Bunge	358	407	765

It is good to note that two of the three schools (Mwanzoni and Kasheshe) are boarding schools and one (Bunge) is a day school. It is cheaper to send children to a day school than a boarding school. The parents also feel more comfortable sending girls to day schools because their children<sup>8</sup> (girls) will always be home every night. The two boarding schools are private, whereas Bunge is a public secondary school. It is also cheaper to send children to public secondary schools. Bunge Secondary School has a higher percentage of girls than the other two schools, partly because it is both public and day. This point will be expanded in “the role of culture” subsection.

Mwanzoni, Kasheshe, and Bunge Secondary Schools are located in rural areas where, like most rural areas in Tanzania, there is lack of access to reliable means of communication, especially Internet and email. There are no computers in schools. Lack

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<sup>8</sup> Please note that in Tanzanian culture the age limit does not matter. The children who are still in school are under the care of the headmaster and their parents.

of computers lead to the lack of resources like computerized problem sets for engagement in problem solving and higher order thinking skills. It is hard for the teachers to assign homework to students and follow up on the progress of the activities. From the interviews I had with the teachers it was clear that the school principals and the teachers themselves were aware of the existence of the gender gap. However, since they work under constraints such as lack of computers, it is difficult for them to implement teaching methods or programs that might help all students learn mathematics. Priority is mostly given to the school's performance in general, not necessarily the individual students' performance. High performing students (boys) are encouraged and they continue to get help using the meager resources they have in order to raise the school's rank in the national examinations.

I learned that teachers also encourage girls to study mathematics. However, the teachers could not give the girls and the boys equal education opportunities and this seemed to be at least partly due to the constraints that the teachers were working under, for instance big classes and the national curriculum. When answering the interview question, "What kinds of role models do you find your students looking up to?" Mr. Isidor, the mathematics teacher at Mwanzoni Secondary School, indicated that in past years almost all members of the staff were male, but recently the number of female teachers has increased; however, it is still very low compared to the number of male teachers. He added that he usually encourages his female students by telling them that they can learn mathematics, because he had a female professor when he was a student at the university of Dar-es-salaam. Mr. Isidor concluded that, "They [girls] need to be encouraged."

Mr. Patrick acknowledged that it is the responsibility of the teacher to encourage students—especially girls—to do well in mathematics. During the interviews, Mr. Patrick indicated that he encourages girls to explore their interests and to consider careers that are typically not thought of for their gender. He cited examples of the women who are in high ranks in the education system or in the government to increase the girls’ confidence in learning science and mathematics subjects.

Table 13

*Teachers at the Three Secondary Schools*

Name of the school	Number of male teachers	Number of female teachers	Total number of teachers
Mwanzoni	18	4	22
Kasheshe	26	4	30
Bunge	19	5	24

Most of the teachers at the three secondary schools are male (see Table 13). This is in line with the factfish website.<sup>9</sup> In 2012 the female teachers were 29.8 percent of the total number of teachers in Tanzania. The information in Table 13 shows that the female teachers at Mwanzoni Secondary School were 18 percent of the total number of teachers, at Kasheshe Secondary School 13 percent, and at Bunge Secondary School 20.8 percent. In general the number of female teachers at each of the three secondary schools was below the average (29.8 percent) in Tanzania. In addition to the small number of female

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<sup>9</sup> [www.factfish.com/statistics-country/tanzania/teachers](http://www.factfish.com/statistics-country/tanzania/teachers)

teachers in secondary schools only male teachers taught mathematics at all three participating secondary schools. Gender inequality in Tanzania is in both the teaching staff and the students.

Although classrooms were overcrowded in the three secondary schools, the number of girls in each classroom was small in relation to the number of boys. Mr. Isidor's class was comprised of 74 students, which means it had 24 girls (32 percent) and 50 boys (68 percent). Mr. Leo's class was comprised of 80 students, which means it had 26 girls (32.5 percent) and 54 boys (67.5 percent). Mr. Patrick's class was comprised of 79 students, which means it had 37 girls (46.8 percent) and 42 boys (53.2 percent). During the interviews, the small number of girls in mathematics and other science subjects and girls' mathematics performance were brought up as big problems in the secondary schools in Tanzania. In his own words, Mr. Isidor explained that Mwanzoni Secondary School completed the girls' dormitory in 2008 to increase the number of girls to be admitted in form five and form six studies (advanced level studies). He insisted that the school had plans to have more girls in mathematics and other science subjects. However, the 2013 form five classroom had boys only. When I asked why there were boys only, he answered that opportunities are given equally to boys and girls but girls do not apply for advanced level mathematics classroom. There were spaces for girls in the dormitories as well as in the classrooms but they were vacant.

### ***Classroom factors.***

Most secondary schools in Tanzania, whether they are boarding schools or day schools, begin classroom instructions at 7:45 a.m every day Monday through Friday. Most classroom periods last 40 minutes, but mathematics lessons are double; that is, they

end after 80 minutes. Students spend 80 minutes without a break in an overcrowded classroom. Researchers and psychologists (Bronfenbrenner, 1977; Fraser, 2002; Patrick, Ryan, & Kaplan, 2007) have associated classroom environments with numerous positive and negative students' academic outcomes. The classroom environments in all classrooms at all three schools I visited were not conducive to student learning. The big number of students in classrooms made the teacher's movement around the class hard. Mr. Isidor expressed his concern that the number of students was too big for one teacher. When answering my probing question, "So when you form group discussions do you mix boys and girls?" He said, "We normally try to help boys and girls work together, but it is hard to move them around in our classrooms because of the big number of students."

Teachers in Tanzania learn to accept situations as they are and continue teaching after they know that there is nothing they can do to make any change. For instance, the crowdedness of the classrooms was a problem beyond the teachers' control. In Tanzania there are a lot of teenagers who want to go to secondary school, but the number of schools is not enough to accommodate all of them. The teenagers' desire for secondary school education forces schools to admit students beyond the classroom capacities. In addition to that, schools do not have enough offices for the teachers. Two or three teachers share an office, which makes it harder for teachers to have office hours where they can use extra time outside classroom hours to help struggling students (mostly girls). Teachers find themselves in situations they cannot change and so learn to ignore the problems like gender inequity.

Language barrier is one of the reasons that girls fail to participate actively in classroom discussions. All three classrooms at the three secondary schools were not

culturally enriched because all students come from the same part of the country, the northwestern corner of Tanzania. Each student in those classrooms speaks at least two languages and for some of the students English is either their third or fourth language. Each student speaks Kiswahili, which is the national language of Tanzania and then two or more languages, including English. Even though English is not their first language, all students and the teachers are required to use English in classrooms. English is used in Tanzanian secondary schools as a classroom medium of communication. However, the teachers used some Kiswahili words to clarify and to stress on some points during instructions. I noticed that all the teachers used Kiswahili to communicate with struggling students (girls). For instance Mr. Leo was teaching how to calculate the mean and decided to hold a short question and answer session in the middle of the lecture:

**Mr. Leo:** Who can tell me the formula to calculate the mean? For example, tell us how to find the mean of 10, 13 and 7. This question goes to females. Tell us the formula to calculate the mean. *“Akina dada twambie kanuni ya kukokotoa mean. Haya Anna.”*

(Meaning: Girls tell us the formula to calculate the mean. Ok Anna).

**Anna:** Jumlisha namba hizo gawanya kwa tatu (Meaning: Add those numbers and divide by three)

**Mr. Leo:** In English now.

**Anna:** Ten plus thirteen plus seven over three.

All three teachers wrote about the solving of mathematics examples in their lesson plans and they also indicated how they were going to lead students to attain a particular mathematical concept. None of the teachers mentioned how he was going to interact with students. At the time of the lessons, students who called out answers were mostly males.

Teachers spent time lecturing and asking questions. The teachers' instructional practices seemed to convey that the teachers had given up on the girls when the teachers engaged more boys than girls in conversation in the classroom.

Mr. Patrick showed concerns about the girls' communication skills. He expressed that girls do not like to contribute during classroom discussions, partly because most of them do not know English well enough to communicate. When I asked him to tell me how he helps girls to participate in class, he said "I speak to them in Kiswahili, if I see they don't understand."

Mr. Leo, the mathematics teacher at Kasheshe Secondary School, liked to use lectures and then spend a session or two on just discussions. During my first interview with him, he explained that he lectures and after he is done teaching he assigns some questions as the classroom homework to be done individually. Mr. Leo said "sometimes I call the students to come to the board to solve the questions. When the students are solving [the problem] they can ask their fellow students to help them through various steps. And if the student fails, I can just help him or her to use good ways and how to go through the steps." In the classroom observation that followed after the interview in which he said he forces the girls, I paid more attention to how often he called on girls and sure enough, he really forced them to answer questions even when they seemed lost and they did not know what to say.

I sketched diagrams of each classroom denoting where boys and girls sat. The size of the room of Mr. Isidor's classroom was a little bigger than the size of the rooms of Mr. Leo and Mr. Patrick. The size of the room of Mr. Leo's classroom was almost equal to the size of the room of Mr. Patrick's classroom. The names of the teachers are

pseudonyms and they are in alphabetical order according to their teaching experiences and the performance of their schools in the district. Mr. Isidor had teaching experience of 20 years and he was from Mwanzoni Secondary School that ranks number one in the district. Mr. Leo had teaching experience of 16 years and he was from Kasheshe Secondary School that ranks number two. Mr. Patrick had teaching experience of 11 years and he was from Bunge Secondary School, which ranks number three.

Mr. Isidor's seating arrangement contained eight rows. The first six rows from left facing the teacher had nine chairs each and the last two rows had ten chairs each. The aisles were very small, making it hard for Mr. Isidor to move around. Girls sat in different spots around the classroom, but wherever the girls were found they sat by each other. At least three girls could be found in each spot.

The tables and chairs in Mr. Leo's classroom did not form rows. Girls occupied the front seats in Mr. Leo's classroom and when I asked him to share with me his strategies to help girls learn mathematics, he said, "I tell girls to sit in front so that if I ask questions I start with them, and then continue with boys."

There were no aisles at all in Mr. Patrick's classrooms. Students walked between tables and behind other fellow students' chairs to go to their seats. Girls sat all over the class. However, the girls sat by each other no matter where they were found.

There were some areas in the classrooms I visited and observed where I could see a boy and a girl sitting by each other, but not that many. The seating arrangements in the classrooms I observed allowed girls to sit by each other and boys to sit by each other. Therefore, during small group discussions most of the groups were one gender; that is, either only boys or only girls. It was very hard to move students around in the classroom

in order to mix them according to gender and differences in achievement, since the classrooms were overcrowded. None of the three teachers showed openly that the classroom seating arrangements were very disturbing to them, partly because the big number of students is a constraint they have to work under, since there is nothing they can do about it.

***Assessment of the teachers' lessons.***

To consider teachers' instructional practices in light of what they expressed in the interviews, I used section three of the classroom observation protocol (see Appendix B) to assess the lessons. I assessed the lessons based on my observation data, field notes and the information gathered during the pre-observation interviews. Table 14 compares the three teachers' instructional practices. The maximum total score each teacher could get was 780. The teacher with a total score of 468 points means that he had an average of 3 points per item, since 3 x 156 is equal to 468. Mr. Isidor had a total score of 359 (46 percent); Mr. Leo, 302 (38.7 percent); and Mr. Patrick, 290 (37.2 percent). All the three teachers had total scores below half of the maximum total score.

Table 14

*Comparing the Teachers*

Code	Number of items	Minimum score	Maximum score	Mr. Isidor	Mr. Leo	Mr. Patrick
Designing a lesson—DL	5	15	75	52	41	40
Implementing a lesson—IL	8	24	120	73	67	64
Respecting Diversity—RD	1	3	15	8	7	6
Monitoring student learning—MSL	14	42	210	93	82	82

Table 14 (Cont.)

Teaching through problem solving—TPS	9	27	135	50	40	33
Questioning—Q	1	3	15	7	5	3
Answering—A	1	3	15	10	7	7
Making a statement or sharing—MS	1	3	15	8	5	4
Justifying—J	2	6	30	10	6	6
Listening—L	1	3	15	6	4	6
Challenging—C	1	3	15	8	8	5
Explaining—E	3	9	45	13	9	11
Predicting or Conjecturing—P	2	6	30	10	11	11
Generalizing—G	1	3	15	3	3	3
Relating—R	2	6	30	8	7	9
TOTAL	52	156	780	359	302	290

These results reveal that the three teachers' instructional practices could increase gender inequity in their classrooms. For instance, in respecting diversity Mr. Isidor got 8 points out of 15 points (53.3 percent); Mr. Leo, 7 points (46.7 percent); and Mr. Patrick, 6 (40 percent). All the teachers scored very low in the ways they paid attention to issues of equity and diversity for students. I rated the teachers' instructional practices on the issues of diversity by looking at how often girls were called on versus how often boys were

called on. At each classroom observations I tallied the number of times girls were called on and the number of times boys were called on (See Table 15).

Table 15

*Teacher-student Interactions*

Classroom observations	Mr. Isidor with boys	Mr. Isidor with girls	Mr. Leo with boys	Mr. Leo with girls	Mr. Patrick with boys	Mr. Patrick with girls
First observation	40	8	20	17	42	12
Second observation	38	11	24	20	40	11
Third observation	31	9	10	6	33	13

When collecting data for Table 15 I focused on how many times each teacher asked boys and how many times he asked girls to answer questions and not on how many boys and girls were involved in classroom interactions. For instance if the teacher asked the same male student to answer questions seven times then I considered it as calling on boys seven times. Of all the teachers Mr. Leo's numbers are the lowest because he used almost one class period for group discussions and the other two class periods were mostly lectures. In general the teachers asked lower-level questions (short answer questions). Airasian (2005) explains that the lower-level thinking questions and statements require recall or memorization of facts. The higher-level thinking questions and statements require performing processes that indicate the understanding of conceptual knowledge and the application of procedural knowledge.

The results of the analysis of the teachers' monitoring student learning show that Mr. Isidor got 93 points out of 210 points (44.3 percent); Mr. Leo, 82 (39 percent); and Mr. Patrick, 82 (39 percent). I rated the teachers' monitoring of student learning by paying attention to the way formal assessments of students were consistent with investigative mathematics. Arthur J. Baroody (1998) reiterates that an investigative approach to teaching mathematics encourages students to explore real-world problems through hands-on activities instead of focusing on rote memorization of facts, formulas, and procedures. The three teachers' instructional practices focused on rote memorization of facts, formulas, and procedures. All the teachers insisted that their students should show the formulas they were using and how they applied the formulas to solve the problems. All the teachers demonstrated formal assessment when they gave students homework. The homework contained the questions from past national examinations and the questions from books suggested by the NECTA. The teachers had all the answers to the questions they gave the students. The focus and the directions of the lessons were always determined by the ideas originating with the teachers and not the students. Research shows that rote learning strategies work for some students but not for all of them (Levenson, 2009; Van de Walle, et al., 2010). It remains important for the teachers to use instructional approaches, such as PSA and FA, which involve all students in class and also treat teaching and learning as two sides of the same coin.

My conversations with the three teachers of mathematics show that all mathematics teachers at each school discussed ways to improve students' mathematics learning at their departmental meetings. The teachers discussed the possibilities or ways that can be used to motivate all students to learn mathematics. The teachers always

discussed the strategies that can help girls to perform better on the national examinations. Huebner (2009) suggests that, “If schools are to produce the mathematicians and scientists we need in the 21st century, teachers must use strategies that bolster both female and male students’ feelings of self-efficacy in math and science” (p. 91). None of the teachers promoted gender equity in his classroom. They interacted more with boys than girls and they often engaged boys in classroom discussions. It looked like the teachers failed to translate what they discussed in their staff and departmental meetings into classroom practices. Also my conversations with the teachers revealed that they separate teaching from learning. It is their understanding that the teachers teach and students have to learn, but teaching and learning should be integral parts of instruction practices (Crockett, 2007). The classroom observations made me want to understand the teachers’ understanding of their role and the importance of culture.

### ***The role of culture.***

During my data collection time I was always at the school early in the morning every day to observe what students do and how they interact outside classrooms. It was interesting to see that at all the schools students walk to classrooms in groups of either only girls or only boys. It was very rare to see a group comprised of boys and girls. I realized that at the boarding schools, the dormitories for boys were built at one end of the school campuses and the dormitories for girls at the opposite end. It came naturally that when students walked to classrooms they were in groups of either only boys or only girls. The culture in Tanzania does not allow a boy and a girl to show their friendship publicly. Therefore, a boy and a girl cannot walk together and especially not in schools. Most tribes in Tanzania allow only those who will get married to sometimes, though not

always, walk together publicly. Since the secondary school students are not yet at the age to get married, if a boy and a girl are seen hanging out in schools it is a sign of immorality. The Tanzanian culture groups the students according to their gender and more boys than girls go to private schools.

Private schools in Tanzania perform better than public schools, partly because most good teachers go to teach in private schools where they can get a decent salary. However, it does not matter where girls go to school; whether to public or private school, most of them already know that their families and community consider them to be weak in mathematics. If a family is able to send only one or two children to private school, boys will get first priority and then girls are sent to public school. Families that can't afford to send children to private school because of financial problems will always send their children to public school. Hence, Bunge Secondary School has a higher percentage of girls than the other two secondary schools that participated in this dissertation study. Families invest more in boys than in girls because after the boys get jobs they are expected to help their families financially and the girls, after they get married, nothing comes to their parents or families. The gender gap in Tanzania is large in almost all subjects in secondary schools. The gap is even bigger in mathematics and science subjects (Kaino, 2009; Masanja, 2004; & Sutherland-Addy, 2008).

When I asked Mr. Isidor to share with me the reasons for the existence of a gender gap in mathematics achievement he explained that “Maybe it is something connected with culture, because formerly most of the students who went to secondary schools were boys. Parents preferred to take boys to secondary school [and] very few girls went beyond primary school.” However, he acknowledged that recently things have

changed and more girls are sent to secondary schools. Answering the same question, Mr. Leo said, “. . . some of the girls fear mathematics and they say that it is a very difficult subject.” When I asked him about the source of the girls’ fear of mathematics, he said that “. . . it all starts with their families and the primary schools. Part of the cause of having fewer girls go for further studies in mathematics in Tanzania is the culture.” Women typically were not encouraged by their families and the community to study mathematics. However, lifestyle in Tanzania is changing and more girls are now going to secondary schools than in the past. In the past girls used to be treated as people who stayed at home and did domestic activities, such as cooking, and after they got to the age of marriage, they got married and had children. But yet the girls are brought up in an environment where they do not consider themselves capable of doing mathematics. Although there are more girls going to secondary schools now than before, still they do not do well in mathematics and science subjects. Mr. Isidor, Mr. Leo, and Mr. Patrick argued that the Tanzanian cultural assumptions might impact how girls feel about mathematics.

#### **Teacher actions and beliefs about gender inequity.**

The classroom culture of all three classes was similar. None of the three teachers involved a broad range of students. All the teachers called on few students, especially boys, to answer questions. Teachers did not encourage active participation of all students. However, during the interviews Mr. Isidor and Mr. Patrick showed that they value active participation of all students, but they find it hard to attend to the needs of each student due to the big number of students. When I asked the teachers to share their strategies on helping all students learn mathematics, they had the following answers: Mr. Patrick said

that, “When you are teaching mathematics . . . you have to attend to individual problems so you have to go to every student, you grade their work . . . since the number of students is too big, I can’t go to individual students. I don’t even have enough space to go around in class and help students during discussions.” Mr. Isidor said that, “I like to give a lot of questions, so my problem here is when the students are many. I do not have time to go through all those, to mark them.” Mr. Leo was different from the other two teachers. He indicated that since girls fear mathematics, he assumes that they will hesitate to try. He lectures most of the time and does most of the example questions. Whenever he asks students to answer questions he first calls on the girls, and if they fail, then that is when he calls on boys.

Teachers seemed to not be paying close attention to how and with whom they were interacting. Part of this dissertation study looked for favoritism during classroom observations. If classroom discussion favors some students, especially the fast learners, then the slow learners lose confidence, both in understanding mathematics and in classroom participation. Empson (2003) states, “if the participant frameworks that emerge in classroom interactions consistently position certain students outside of the practices that the teacher takes to represent mathematical competence, one may expect student disengagement as a direct consequence” (p. 318). This practice reduces the low achievers’ access to mathematics power. In this respect, mathematics education takes on a “political or social agenda—who has mathematical power and who do not” (Moody, (2001), p. 274). We can expect the low-achieving students to participate fully in the mathematics discussion, be it in small or in big groups (whole class) if we (teachers) give them access to mathematics power by showing them that we value their mathematics

thinking by explaining what they are expected to do and by giving them opportunities to share their strategies with their peers (Van de Walle, et al., 2010).

During interviews the teachers showed that they were aware of the existence of gender inequity in mathematics achievement in Tanzanian secondary school classrooms. They said that boys perform better than girls in classrooms as well as in national examinations. They also said that the girls do not like mathematics.

***Boys perform better than girls.***

All the teachers admitted that boys perform better than girls in classrooms as well as in national examinations. The Tanzanian government, principals and teachers at the secondary schools are aware that boys perform better than girls, but they still do not know what to do better in order to improve the girls' performance. Mr. Isidor stated that, "even here at school level we normally try to give some rewards to those who perform well in mathematics, but girls seem to lag behind generally." Mr. Leo shared his experience of teaching a class with boys and girls, and he said that, "boys are always ready to participate in classroom discussions. However, very few girls will even try to answer a question." Mr. Isidor and Mr. Patrick had similar ideas as Mr. Leo's on the girls' participation in the classroom.

Mr. Patrick called on boys more often than girls during classroom discussions. Whenever Mr. Patrick called on girls to answer questions and participate in classroom discussions, he did not wait long enough for the girls to respond. He immediately asked boys who had their hands up to answer the questions. The purpose of one of Mr. Patrick's lessons I observed was "statistics" and when he finished teaching how to calculate the "mean of data" he asked students to define "a mode of a set of data":

**Mr. Patrick:** What is a mode of a set of data? Tekla! (He asks a girl although she did not has her hand up)

**Tekla:** (Tekla does not answer)

**Mr. Patrick:** Tekla is sleeping. Can you tell us the definition? Ok Willie, you tell us (He asks a boy who had his hand up).

**Willie:** The mode of a set of data is the value in the set that occurs most often.

**Mr. Patrick:** Very good!

I was curious and I needed to confirm what I saw and when I asked him during one of the interviews why he did not wait long enough for the girls to answer the questions he said, “From my experience boys perform better than girls, and if the girls can’t answer questions then I ask boys, hoping that girls will learn from boys.”

At the interview on gender gap I asked Mr. Isidor to share with me his experience of teaching boys and girls as it is seen in the following conversations:

**Fr. John:** What has your experience been like working with co-educational classes?

**Mr. Isidor:** When I compare performance of boys with that of girls, the girls tend to lag behind boys. Unlike other schools where girls are alone, they perform very well. When you mix boys and girls, the girls tend to lag behind. That is my observation.”

Mr. Leo had the following responses to the same question:

**Mr. Leo:** Yeah, we find that especially boys are very, very much volunteering in the class, to put the efforts in this subject [mathematics] rather than girls. Girls are very few who do that, they try their level best but the are few compared with boys.”

**Fr. John:** So you know that girls hesitate to participate . . . (he interrupts)

**Mr. Leo:** Yes, yes even in general you find that boys perform better than girls.

**Fr. John:** Why do you think the boys perform better than girls in mathematics?

**Mr. Leo:** I think there is inferiority complex in the subject. Some of the girls fear so much and say that this subject is very, very difficult. They normally apply for arts subjects rather than science subjects.

*Girls don't like mathematics.*

All three teachers said that girls do not like mathematics. During the interview I had with Mr. Isidor about gender gap in Tanzanian secondary school classrooms, I asked him the following question; “What has your overall experience been like teaching at Mwanzoni Secondary School?” He explained that, “We are having a problem with mathematics all over this country, but then the problem is even more serious when it comes to girls; that is gender issue.” He continued by saying that, “Most girls do not like to take mathematics; now we don't know what goes wrong. Not only mathematics, even sciences in general.” He spoke from his long experience of teaching mathematics at Mwanzoni Secondary School and insisted that “. . . girls are not interested in mathematics.” He understood that the efforts to motivate girls in mathematics start from the government level. But still girls do not like mathematics. Responding to the same question Mr. Leo said that, “Not only do the girls dislike mathematics but they also do not want to try to learn it.”

In all three classrooms students who asked questions to clarify their understanding of mathematics ideas or procedures were mostly boys. When I asked the teachers to explain why girls never ask questions, they all said that the girls do not like mathematics. The girls come to classes because it is the rule of the National Examinations Council of Tanzania (NECTA) that all students should study mathematics. In all three classrooms

very few girls attempted to participate in classroom instructions by having their hands up. Mr. Leo said that only boys volunteer to answer questions in class. Whenever girls answered questions, it was after they were asked to do so even if they did not have their hands up. After Mr. Leo said that the boys perform better than girls our conversations continued as follows:

**Fr. John:** With that in mind, boys are better than girls; do you do anything to help these girls learn mathematics?

**Mr. Leo:** Of course, since girls don't like mathematics, I normally select them to force them to try rather than boys. I normally start with girls and if they fail then that is when I select boys."

*Not having enough time to solve mathematics questions.*

Mathematics teachers teach and students learn under the pressure of not having enough time to solve enough mathematics questions in preparation for the national examinations. During the interviews on PSA one of the questions I asked was: "Do you give your students opportunities to share their answers with their peers?" If yes, please explain how and when, and if not, why not? Each teacher had the following answers:

**Mr. Isidor:** Yes but we [teachers] work under pressure (he paused) under pressure to finish the syllabus. Therefore to be honest with you, I ask short questions during my lectures to get short answers. We have many students, a lot of students in one class.

**Mr. Leo:** It is very hard because of the number of students in class. It is very big as you saw yourself. Sometimes I lead the discussion myself because it is hard to call a student to come forward because no space in class to move.

**Mr. Patrick.** Yes I do but not always because I want to continue and finish the syllabus before the national examinations.

Throughout my data collection I learned that there was always a pedagogical tension in the teachers' life created by what was to be covered within a year to meet the NECTA requirements. The teachers in Tanzania are always in a rush to finish the national mathematics syllabus.

There is a national curriculum system in Tanzania. All secondary schools use similar books and syllabus in each subject throughout the country, and at the end of each program all students do the same national examination written by the NECTA. Therefore, it is the responsibility of NECTA to provide all primary schools as well as secondary schools with the national syllabus. NECTA also determines the kind of textbooks to be used in schools. It leaves the teaching of materials and the completion of the syllabus to individual administrations of the schools. The teachers teach thinking that if they do not finish the syllabus, there is no way the students will perform well in the national examinations. All three teachers explained that they give students a lot of questions to practice mathematics formulas. Mr. Isidor even said, "If students solve a lot of questions . . . they will do well in national examinations."

Teachers who see that students need to have time to solve more mathematics problems resort to creating groups of students who are interested in mathematics and schedule time different from the classroom lesson times in order to solve more mathematics questions. All the teachers spontaneously mentioned this multiple times in response to my general questions about the efforts made by the teachers to help students improve mathematics learning. The U.S mathematics reformers hold that groups that do

not involve all students violate the goal of mathematics reform, that is, mathematics for all (NCTM, 2000).

All the teachers expressed their concern about low performance of the girls in mathematics. They mentioned that the sources of the gender-gap in mathematics achievement are primary school mathematics teachers, class sizes, culture and the girls' attitude. Mr. Isidor said that, "And you see one thing which causes all these problems, because in primary school level most of the teachers are not interested in mathematics." He explained that most mathematics teachers in primary school failed mathematics in the national examinations when they graduated from form four. Mr. Isidor said, ". . . You see people getting division 4 are taken to a teachers college. They have failed mathematics and after their training they are told to teach mathematics." He noted that when students join secondary schools they are not well prepared for secondary mathematics. Mr. Isidor said, "They lack basics in mathematics, basic knowledge."

While answering the question as to why he thought the girls' performance is lower than the boys' performance in secondary schools, Mr. Leo replied that, "I think the environment from primary level [primary school] contributes a lot towards poor performance of girls [in secondary schools]." He explained that there are students who join secondary schools and yet they cannot solve simple mathematics questions such as finding the area of simple figures like triangles and squares.

I used the following question to get the teachers' perspectives on assessment: "What kinds of assessment techniques tell you the most about what students are learning?" All the teachers explained that they give students questions to do as homework and then they grade them. However, Mr. Isidor said, "I give them questions to do after

class and I want to give them more questions but I don't do it because I can not grade all of them, . . . many students.”

### **Summary**

The rationale for PSA (Hiebert & Wearne, 2003; Lubienski, 2000) and FA practices (Black & Wiliam, 1998a; Ruiz-Primo & Furtak, 2006) is to improve students' achievement of intended instructional outcomes. To improve students' learning a teacher who uses PSA and FA should establish a classroom culture in which the teacher and students are partners in learning. The teacher also should establish trustful classroom environment in which students feel safe to provide constructive feedback. All the teachers seemed to agree that small group discussions provided multiple opportunities to help all students learn mathematics. However, Mr. Isidor and Mr. Patrick did not use small group discussions because they said classrooms were overcrowded. Mr. Leo used small group discussions at one of the three classes I observed. I noticed that the teachers did not always do what they said during interviews. For instance, they all said that they respected diversity, but the observation results show that they scored very low on the Likert scale in the respecting diversity area. The observation and interview data indicate that the teachers were using very little PSA or FA practices largely due to contextual constraints, for example huge classes, lack of teacher's pedagogical knowledge, lack of instructional resources like computerized problem sets for engagement in problem solving and higher order thinking skills, and a gender bias that is endemic in the society at large. Culture plays a pivotal role in the teaching and learning of mathematics (Atweh & Ochoa, 2001; Crockett, 2008). Atweh and Ochoa (2001) insist that, “Teachers in the classroom are in a unique position to understand the real context of their students and

classroom and thus can adapt the reforms to their students' needs" (p. 181). But in some countries like Tanzania, the education system does not give the teachers opportunities to participate fully in the curriculum reform although they are the ones who know what is happening in classrooms. Instead the teachers do whatever they can to meet the Ministry of Education's requirements. As a result the teachers concentrate on finishing the Ministry of Education's syllabus as opposed to helping all students, especially low achievers (girls in this case), learn mathematics.

## Chapter V

### **Discussion and Conclusion**

Following from my early research study, this dissertation study set out to explore mathematics instruction and the gender gap in mathematics achievement in Tanzanian secondary school classrooms. This chapter is divided into five sections. The first section is on the synthesis of the empirical findings; the second section is on the limitations; the third section is on the implications for teachers; the fourth section is on the implications for policy makers and teacher educators, and the fifth section is on the implications for future research.

#### **Synthesis of the Empirical Findings**

In this section I will give the summary of what Tanzania is trying to do to help both boys and girls receive more equal education and I am going to look at how well instruction is meeting those goals, and the key barriers that seem to hinder implementation of the government vision.

The education for all (EFA) and the education and training policy (ETP) are the policy programs in Tanzania that embody Tanzania's priorities and commitments. Tanzania (formerly Tanganyika) had EFA as its priority since independence. Tanganyika received its independence from the United Kingdom as a commonwealth realm on December 9, 1961; the island of Zanzibar became independent from the United Kingdom on December 19, 1963. Tanganyika united with Zanzibar on April 26, 1964 to form the United Republic of Tanganyika and Zanzibar. The United Republic of Tanganyika and Zanzibar was renamed on October 29, 1964 and became the United Republic of Tanzania. In 1995 the Ministry of Education and Culture in Tanzania formulated the

ETP. The role of ETP is to guide, synchronize and harmonize all structures, plans and practices to ensure access, equity and quality education at all levels. From the Tanzania national website<sup>10</sup> on the education link we read that “the overall objectives of introducing education reforms together with other policy initiatives is to ensure growing and equitable access to high quality formal education.” However, evidence from several studies, including Masanja (2004), my early research (Zilimu, 2009) and this dissertation point to the fact that a mathematics achievement gender gap still exists in Tanzanian secondary schools.

After Independence from the British in 1961 the first president of Tanzania Mwalimu (which translates to teacher) Julius Kambarage Nyerere saw education as an important element in reforming the country. Nyerere set self-reliance and cooperation with others as the government’s goal, and he believed that to achieve that goal the government had to educate all its citizens. The website of the African Studies Center, University of Pennsylvania<sup>11</sup> with the link of Tanzania in the “education” section, states that “education played an important role in the reforms that Nyerere proposed after independence.” The government of Tanzania has determined to achieve an important goal, that is, EFA because it (Tanzanian government) is aware of the fact that the provision of education is a basic human right.

It is a widely accepted fact in Tanzania that teacher education is a crucial support instrument for achieving EFA. In the 1970s Tanzania built an extensive education system in which the universal primary education (UPE) campaign was started. The main goal of

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<sup>10</sup> See <http://www.tanzania.go.tz/education.html>

<sup>11</sup> See <http://www.africa.upenn.edu/NEH/education.htm>, East Africa Living Encyclopedia.

UPE was to enable all children, boys and girls alike, to complete primary schooling. In the 1970s there was a great need for primary school teachers so the government under the UPE campaign decided to recruit more teachers. All young people, boys and girls, who had completed seven years of primary school were given an examination, and those who passed were employed as primary school teachers. The government opened centers where the teachers went through intensive training while teaching at the same time. They had yearly short courses in which they went to the teacher training colleges (TTC) for three months and came back to their schools and continued teaching. This was done for three consecutive years (1976, 1977 and 1978) and stopped after that. This method of recruiting teachers worked out very well in reducing the demand for primary school teachers but the quality of education, which was given to the pupils, went down.

Wepukhulu (2002) reports that, “the government [Tanzanian] desire to improve the provision of quality education and training resulted in the formulation of the Education and Training Policy (ETP) in 1995” (p. 4). The ETP encompasses the entire education and training sector. ETP emphasizes the government’s continued responsibility in the provision and financing of more and better basic education. At the same time, it calls for a reduction in untargeted subsidies through increased cost-sharing, liberalization of private education and training at all levels, and decentralization of authority. The government of Tanzania has increased enrollment in primary schools since 2002. With the help of the ETP, Tanzania has been enabled to achieve increased enrolments in all levels of education.

In all the classrooms of the three participating teachers the seating arrangements allowed students to sit according to gender (boys sat by boys and girls sat by girls).

However, I was unable to conclude whom this seating arrangement favored, boys or girls or neither. My guess would be, most girls felt more comfortable working in a group of girls only since the culture brings them up feeling inferior to boys. The teachers interacted more with boys than girls, that is, they engaged more boys than girls in classroom discussions. One of the effects of gender inequity in the classroom is an achievement gender gap (Adams, 1998; Zilimu, 2009). The quantitative results of my early research study (Zilimu, 2009) show that the achievement gap between boys and girls widened in classes in which boys were openly favored, for instance in Mr. Patrick's class.

All participants in the study acknowledged that a gender gap exists in Tanzanian secondary schools. I observed various instances of gender inequalities that could lead to a mathematics achievement gender gap. The number of girls at each school was smaller than the number of boys and also the number of male teachers was far larger than the number of female teachers. All mathematics teachers at the three schools were males. Seating patterns in all classrooms allowed boys to sit by each other and girls to sit by each other. Adams (1998) researched on the problems that may be caused by gender inequalities in the classroom and she observed that female students continue to score as much as 55 points less than males on the influential SAT mathematics test. All the participating teachers in my dissertation stated that the problem of the gender gap in mathematics achievement has its source in the instructional practices and the content knowledge of the primary school teachers. While answering the question, "Why do you think there is gender gap in secondary school mathematics?" Mr. Leo said in his interview, "I think even environment from primary level. In primary level they [teachers]

are not strict in this subject [mathematics]. They are just rushing through.” (Interview on 03/07/2013 at 10am) The question of what the secondary school teachers do to correct the problem they inherit from primary schools remained unanswered.

Most of the interview data supported the observation data. However, there were some contradictions between the observation data and the interview data. For instance I observed that girls and boys did not get equal opportunities for learning. However, all the teachers said that they always try to help the girls to learn mathematics but girls do not like mathematics. I realized that the teachers unconsciously based their instruction on such false stereotypes. Based on my data I speculate that the Tanzanian culture of favoring boys in almost everything including education influenced the teachers’ instructional practices.

I observed that secondary school mathematics teachers’ instructional practices might contribute to the existence of the gender gap in mathematics achievement. For example, using questions from the context, which is familiar to the students (real-life problems), is a characteristic of PSA that research shows it helps girls to do well in their performance (Hyde, et al., 2008; Pomerantz, et al., 2002). The teachers used questions straight from the books and none of the questions were real-life problems. It is very important in PSA and FA practices that all students show confidence in mathematics and participate actively in mathematics classroom discussions. However, in all the classrooms I observed boys were more often called on than girls. It is also important in a PSA and FA practices that teachers spend more time, patiently with their students, especially the lower achievers and wait longer after asking a question before calling on someone else. Researchers explain that the instructional practices in which the teachers wait longer after

asking a question gives girls more time to collect their thoughts and may allow more students to raise their hands (O'Connor-Petruso, et al., 2004; Sutherland-Addy, 2008; Zhu, 2007). I observed that the teachers did not wait long enough after asking a question. Whenever a student was unable to answer the question right away the teachers switched to a different student.

In curriculum reform instructions students are expected to define problems, formulate conjectures, and discuss the validity of solutions with their peers. This pattern is consistent with that presented by Hiebert and colleagues (1996) but it is not reflected by the empirical findings of this study. Nowhere in this study did I see clear evidence of the teacher in the classroom giving opportunities for students to share their mathematical thinking so that the rest of the class could learn from their fellow students. When the teachers used classroom discussion techniques to teach mathematics, they just asked students to provide procedures or algorithms or memorized rules. For instance Mr. Patrick, during the second classroom observation, asked the students to use the procedures. He told them to use the procedures he used to solve one of the questions he gave the whole class. Teachers like Mr. Patrick will miss the opportunities to act formatively, that is, to improve mathematics learning and teaching during instruction if they do not monitor and take time to understand students' mathematical thinking. An ineffective use of PSA and FA may widen the achievement gap instead of bridging it.

### **Limitations of this Dissertation Study**

One of the limitations of this dissertation lies in the fact that I am the only observer in the whole process of collecting data, which weakens the reliability of the observational data. Reliability means that if a later investigator does the same case study

over again using the same procedures he or she should arrive at the same findings and conclusions. According to Yin (2009), “a common procedure to increase the reliability of observational evidence is to have more than a single observer making an observation – whether of the formal or the casual variety. Thus, when resources permit, a case study investigation should allow for the use of multiple observers” (p. 111). Because the nature of dissertation study does not allow more than one observer, I enhanced reliability by clearly documenting the procedures followed in this dissertation study. Yin (2009) explains that one prerequisite for allowing another investigator to repeat an earlier case study is the need to document the procedures followed in the earlier case.

In order to deal with the documentation problem, I developed and reviewed the case study protocols, which helped me during classroom observations and the teachers’ interviews. I also developed a case study database during the data collection phase to help me organize and document evidences from multiple sources; interviews and observations. A case study database facilitates the availability of the raw data for any critical reader if he or she wants to inspect the raw data that led to the case study’s conclusions.

Another limitation of this dissertation is the nature of the sample of participants. The findings were based on three mathematics teachers selected from three different schools based on their schools’ level of performance in the national examinations. The three schools were from high performing group in the district. The findings left out the experiences of the teachers from the lowest performing schools. However, I believe that I got good information about the nature of gender gap in mathematics achievement by observing and interviewing the teachers from similar environments. The selection of the teachers had nothing to do with the teachers’ experiences in teaching mathematics, nor

had it anything to do with their knowledge level about problem solving approach, classroom discourse, and classroom formative assessment. Although the term “generalizability” holds little meaning for most qualitative researchers (Glesne & Peshkin, 1992; Yin, 2009), I still used a multiple case study approach to replicate findings across the three mini cases. However, the results were biased because they represent only what is happening in the three teachers’ mathematics classrooms at the three schools. Yet I still believe that the findings reflect how most Tanzanian secondary school mathematics teachers understand gender gap in relation to their teaching practices.

The third limitation of this dissertation is I only spent one month in the site of research collecting data due to the fact that I am a full time Catholic priest and a full time student. The lack of intensive, long-term involvement seems to threaten the validity of my data. However, my being in the site before increases the credibility of my conclusions. This was when I was collecting data for my early research study. I also continued to communicate with the participants via email and phone calls for member checking purposes.

### **Implications for Teachers and Teacher Educators**

If I were a mathematics teacher in a Tanzanian secondary school and read the portrait of gender inequity practices offered in this dissertation study I would be concerned with what I can do to promote gender equity in my classroom. Here are a few suggestions that could help both boys and girls receive more equal education in Tanzania.

First, suggest to the administration that teachers need training in gender equity. The results of this dissertation study show that Tanzanian secondary schools still need mathematics teachers who are well vested not only in content knowledge but also in

pedagogical knowledge with the insistence on how to reduce gender achievement gap.

The fact that teachers unconsciously base their instructional practices on false stereotypes such as girls are not good at mathematics or only boys are good at science merits further research to find ways to train teachers to use different strategies to diminish the perceived gender gap.

The efforts put into the education of children will produce good fruits if the focus is more on the efforts to educate and train those teachers who are involved in the education of the children. Renes (1970) states that “for if one undertakes to study the cultural and socio-psychological, as well as the school-sociological and educational aspects of child training, the attention is soon drawn to those men and women who are charged with the task of training and educating, and ultimately also to the way in which those teachers are prepared for their tasks.” (p. 2)

Second, each teacher needs to do a survey of gender inequity in his or her classroom. Teachers should focus on how often girls are called on versus how often boys are called on. Teachers can ask other teachers to observe lessons and give feedback. This is a kind of professional development for in-service teachers.

### **Implications for Policy Makers**

The efforts of the Tanzanian secondary schools and of the government at large to improve students’ performance in mathematics need to be revisited in order to further understand and minimize the mathematics achievement gender gap in Tanzania. The findings of this dissertation study suggest that the Ministry of Education in Tanzania needs to pay attention to the conditions in which teachers work. For instance I explained in the results chapter that the classrooms were overcrowded and there were lack of basic

communication devices within the schools. Reducing class sizes will help the teachers to address reform issues since they will work in ideal conditions. The size of classes need to be reduced in order for the teachers to use the instructional practices such as PSA and FA, which research shows enhance the achievement of all students especially the low achievers.

The empirical findings of this study show that the current Tanzanian education policies, nation wide and at the schools' administrative level insist on diminishing the achievement gender gap in mathematics. However, the teachers showed that the efforts to diminish gender gap have not helped to increase the girls' confidence in mathematics. The Ministry of Education in Tanzania needs to improve the teachers' professional development programs to help the teachers with ways to promote gender equity in their classrooms. Most of the efforts for improving mathematics achievement in Tanzanian secondary schools are dedicated to the improvement of the teachers' content knowledge; however, instructional interventions such as PSA and FA improve students learning especially lower achievers (Black & Wiliam, 1998a). Ruiz-Primo and Furtak (2006) said, "The teacher whose students had the highest performance on our tests was the teacher who held the most discussions, asked the most concept-eliciting questions, and employed the greatest diversity of strategies that used information she had gained about student understanding" (p. 231). Ruiz-Primo and Furtak (2006) believe that one of the factors that could influence the students' performance is the type and the quality of assessment conversations in which the teachers engage with their students. This belief overlaps with PSA (Van de Walle, et al., 2010).

## **Implications for Future Research**

The scale of this dissertation study is extensive at the classroom level. This dissertation explored the teachers' understandings of their teaching practices and how their perceptions reflect PSA and FA in the context of their instructional practices. It also explored how their teaching practices, the perceptions of their teaching practices, and their classroom contexts perpetuate gender gaps in mathematics achievement.

Throughout the interviews, the three mathematics teachers expressed that they were aware of the existence of gender inequities in mathematics achievement. To generate achievable policy strategies and develop goals with regards to the mathematics achievement gender gap in Tanzanian schools more studies are needed that try to examine the impact of the instructional practices that I identified in this dissertation study on Tanzanian girls and boys. For instance, is allowing students to sit where they want a bad practice? What should a teacher do when asking a question and a girl has no idea how to answer—in this context, would it be better if teachers did not put girls on the spot? Or would it be better if they strictly asked easy questions of girls to build their confidence? Or perhaps they should help the girls answer challenging questions by asking a series of smaller questions? This dissertation study unearths some of these tensions about decisions teachers make on a daily basis. Exploring those tensions as future research strategies can facilitate the attainment of the Tanzanian government goal, which is EFA.

The results of this dissertation study reveal that the teachers' instruction does not reflect a PSA or FA practices. Ali, Hukamdad, Akhter, and Khan (2010) suggest that when the mathematics teachers use a PSA, it improves the academic achievement of the

students. Researchers show that when the principles of FA permeate the classroom environment there are strong achievement gains in student performance and the largest gains accrue to the lowest achievers (Black & Wiliam, 1998a; Meisels, et al., 2003; Rodriguiz, 2004). Hence the use of PSA and FA in the teaching of mathematics appears promising for enhancing the achievement of the students in Tanzania. However, it is important to note that the teachers in Tanzania work in vastly different contexts from many of those where PSA and FA have been studied. The question of how much those findings about the effectiveness of PSA and FA practices would transfer to a Tanzanian context with class sizes of 70-80 students and in a context in which girls are not generally encouraged to make their voices heard in academic settings remained unanswered. The contextual factors in Tanzanian classrooms is one of the reasons the research on the achievement gender gap in the context of Tanzanian schools leaves behind very important questions on the relationship between instructional practices and gender gaps.

This dissertation study looks at gender equity from the in-service teachers' perspective, but the students' understanding of gender inequity in the context of classroom instructions must be explored. Researchers should explore whether the students, boys and girls, are aware that gender gaps in mathematics achievement and classroom experiences exist, because students should take an active role in their learning (NCTM, 2000; Stiggins, et al., 2006; Van de Walle, et al., 2010).

Further research is needed to explore the pre-service teachers' understanding of a mathematics achievement gender gap. Gender gaps might be narrowed if the teacher training programs are improved to meet the challenges of equity in mathematics education. According to the *Principles and Standards for School Mathematics* (NCTM,

2000) what is needed is to improve the education system so that it focuses on equity.

Teacher education includes both pre-service and in-service teacher education. Both areas have one common objective, which is to improve teaching and learning approaches.

Discussing the mathematics classrooms that promote understanding, Secada and Berman (1999) said, “If educators fail to purposefully try to incorporate an equity perspective within the teaching of mathematics for understanding, then there is a very real danger that this new and evolving form of teaching mathematics will, in fact, exacerbate group-based differences and treat students unfairly” (p. 34).

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*Appendix A*

*Sensitivity to Gender, Problem Solving and Formative assessment in Mathematics:*

*Classroom Observation Protocol*

I adapted this classroom observation protocol from Local Systemic Change (LSC) classroom observation protocol by Horizon Research, Inc., Oregon Mathematics Leadership Institute (Tomlinson) (Tomlinson) classroom observation protocol, and Reformed Teaching Observation Protocol (RTOP).

**I. Background Information**

**(I collected this information once per teacher prior to the classroom observations and the teachers' interviews.)**

Pseudonym of teacher observed: \_\_\_\_\_

Pseudonym of school: \_\_\_\_\_

Years of teaching \_\_\_\_\_ Teaching certification \_\_\_\_\_

**(I filled this out prior to each classroom observation.)**

Date of observation: \_\_\_\_\_

Time of observation:

Math class began: \_\_\_\_\_

Math class ended: \_\_\_\_\_

## II. Contextual Background and Activities

1. **Classroom Demographics and Context** (Adapted from LSC. Made some modifications and added D, E and F)

**(I filled this out after each classroom observation just to make sure that I was having the same number of students all the times I observed classes.)**

- A. What is the total number of students in the class? \_\_\_\_\_ (Give exact count)
- B. What is the number of boys in the class? \_\_\_\_\_ (Give exact count)
- C. What is the number of girls in the class? \_\_\_\_\_ (Give exact count)

**(I filled this out before classroom observations and teachers' interviews. I asked the teachers before I arrived on the sites to look for the information in D, E and F for me.)**

- D. What is the total number of students at the school? \_\_\_\_\_
- E. What is the total number of boys at the school? \_\_\_\_\_
- F. What is the total number of girls at the school? \_\_\_\_\_
- G. What is the teacher's gender? Male \_\_\_\_\_ Female \_\_\_\_\_
- H. Rate the adequacy of the physical environment.

**(I filled this out once after the first classroom observation of each teacher. After the second and the third classroom observations, I only confirmed that the physical environments of the classrooms were still the same.)**

1. Classroom resources

- 1. Sparsely equipped
- 2.
- 3.
- 4.
- 5. Rich in resources

2. Classroom space:

- 1. Crowded
- 2.
- 3.
- 4.
- 5. Adequate space

3. Room arrangement:

- 1. Inhibited interactions among students
- 2.
- 3.
- 4.
- 5. Facilitated interactions among students

**2. Purposes of Lesson** (Adapted from LSC. I changed the topics taught to match the ones taught in Form four classes in Tanzania)

**(I filled this out during the pre-observation interviews.)**

A. Indicate the primary content area of this lesson or activity (*In general, choose just one.*)

- 1. Sequences and series
- 2. Probability
- 3. Vectors
- 4. Quadratic expressions
- 5. Further logarithms
- 6. Formulae and variations
- 7. Matrices and Transformations
- 8. Statistics
- 9. Loci
- 10. Trigonometry
- 11. Three-dimensional geometry

B. Indicate the primary intended purpose(s) of this lesson or activity. (*In general, choose just one*).

- 1. Identifying prior student knowledge
- 2. Introducing new concepts
- 3. Developing conceptual understanding
- 4. Reviewing mathematics concepts
- 5. Developing problem-solving skills
- 6. Learning mathematics processes, algorithms, or procedures
- 7. Learning vocabulary/specific facts
- 8. Practicing computation for mastery
- 9. Developing appreciation for core ideas in mathematics

- 10. Developing students' awareness of contributions of mathematicians of diverse backgrounds
- 11. Assessing student understanding

**3. Classroom Instruction** (Adapted from LSC. I added C which is not in LSC)

**(I filled this out after observing the entire lesson)**

**A. Indicate the major way(s) in which student activities were structured.**

- As a whole group
- As small groups
- As pairs
- As individuals

**B. Indicate the major way(s) in which students engaged in class activities**

- Entire class was engaged in the same activities at the same time.
- Groups of students were engaged in different activities at the same time (e.g., centers)

**C. Please provide specific times for each lesson component:**

\_\_\_# Minutes whole group instruction/discussion (generally teacher-led instruction)

\_\_\_# Minutes small group work on experiments/tasks that are part of lesson/instruction

\_\_\_# Minutes individual work on experiments/tasks that are part of lesson/instruction

\_\_\_# Minutes for homework in small groups (most students collaborating substantially)

\_\_\_# Minutes for homework as individuals (most work done individually without collaboration)

**D. Indicate the major activities of students in this lesson.** When choosing an “umbrella” category, be sure to indicate subcategories that apply as well. (For example, if you mark “listened to a presentation,” indicate by whom.)

1. Listened to a presentation:

- a. By teacher (would include: demonstrations, lectures, media presentations, extensive procedural instructions)
- b. By student (would include informal, as well as formal, presentations of their work)
- By guest speaker/”expert” serving as a resource

2. Engaged in discussion/seminar:

- a. Whole group
- b. Small groups/pairs

3. Engaged in problem solving/investigation:

- a. Worked with manipulatives
- b. Played a game to build or review knowledge/skills
- c. Followed specific instructions in an investigation
- d. Had some latitude in designing an investigation

- e. Recorded, represented and/or analyzed data
- f. Recognized patterns, cycles or trends
- g. Evaluated the validity of arguments or claims
- h. Provided an informal justification or formal proof

4. Engaged in reading/reflection/written communication about mathematics

- a. Read about mathematics
- b. Answered textbook/worksheet questions
- c. Reflected on readings, activities, or problems  
individually or in groups
- d. Prepared a written report
- e. Wrote a description of a plan, procedure, or problem-solving process
- f. Wrote reflections in a notebook or journal

5. Used technology/audio-visual resource:

- a. To develop conceptual understanding
- b. To learn or practice a skill
- c. To collect data (e.g., probe-ware)
- d. As an analytic tool (e.g., spreadsheets or data analysis)
- e. As a presentation tool
- f. For word processing or as a communication tool (e.g., email, internet, web)

6. Other activities

- a. Arts and crafts activity
- b. Listened to a story
- c. Wrote a poem or story
- d. Other (please specify) \_\_\_\_\_

**E. Comments**

**(I wrote my comments after each classroom observation)**

Please provide any additional information you consider necessary to capture the activities or context of this lesson. Include comments on any feature of the class that is so salient that you need to get it “on the table” right away to help explain your ratings; for example, the class was interrupted by a fire drill, the kids were excited about an upcoming school event, or the teacher’s tone was so warm (or so hostile) that it was an overwhelmingly important feature of the lesson.

### III. Ratings

In Section two of this form, I documented what occurred in the lessons. In this section, I rated each of the lessons based on my classroom observations and field notes.

**(I collected this information immediately after each classroom observation)**

(1 = Never, 2 = Very little, 3 = Some, 4 = Mostly, 5 = Consistently)

Table A1

*Lesson Design and Implementation* (Adapted from LSC, OMLI and RTOP)

<p><b>1. The design of the lesson reflected careful planning and organization.</b></p> <p><i>(Default 4 – because we would expect that this would occur “mostly.” Give 5 if teacher clearly carefully prepared materials, good example problems if relevant, and had deep, probing questions prepared. Give 3 or lower if teacher fumbled, or missed lots of opportunities, or did not prepare any probing questions or examples that get at meaning or main point of lesson, or is a very uninspired lesson (e.g., stood and read from the book)).</i></p>	1	2	3	4	5
<p><b>2. The design of the lesson incorporated tasks, roles, and interactions consistent with investigative mathematics.</b></p> <p><i>(Rate 1 if lesson design involved primarily teacher lecture or book reading – no questions planned, no problem/investigation planned as part of main instruction in lesson. Rate at least 2 if one or more of those elements were included in some way – e.g., a “2” might be that some questions were planned to generate student interest and participation as part of interactive teacher lecture.)</i></p>	1	2	3	4	5

Table A1 (Cont.)

<p>3. <b>The lesson had a problem/investigation-centered structure (e.g., teacher launched a problem/investigation, students explored, and teacher led a synthesizing discussion).</b> <i>(Could involve more than 1 cycle of this. This isn't judging quality of the structure – is it there?)</i></p>	1	2	3	4	5
<p>4. <b>The instructional objectives of the lesson were clear and the teacher was able to clearly articulate what mathematical ideas and/or procedures the students were expected to learn.</b> <i>(Draw from teacher pre-observation interview and what is done in lesson. Note that this should be about what students will learn and not just “do” – e.g., “students will count M&amp;M’s” is not a clear math goal, whereas “students will learn the difference between median and mode” is) Lesson should match stated learning objectives to get at least a 4. Lesson must match AND objectives are clear and focused very specifically on what kids will learn to get a 5. If lesson objectives are not specific about what kids are to learn, then 3 or less (e.g., the objective is to learn about “fractions” or “plants” – what ABOUT these things are kids supposed to learn?)</i></p>	1	2	3	4	5
<p>5. <b>The lesson design provided opportunities for student discourse around important concepts in mathematics.</b> <i>(Teacher-student discourse counts as discourse. Teacher leaves room for student talking (to each other or whole class) this counts. If lots of student contributions related to important topics but not necessarily probing deeply default 3. Need opportunities for student-student interaction and probing deeply into important ideas to get a 5. Pay attention to design and potential opportunities – e.g., if lesson well designed and teacher tries to generate deep discourse but kids are not actually taking up the opportunities, you could still rate highly).</i></p>	1	2	3	4	5

Table A1 (Cont.)

<p>6. <b>Mathematics was portrayed as a dynamic body of knowledge continually enriched by conjecture, investigation analysis, and/or proof/justification.</b> <i>(Do kids get idea that conjecturing, exploring and proving is what math is all about? Or is it about following rules given by teacher or book?)</i></p>	1	2	3	4	5
<p>7. <b>The teacher appeared confident in his ability to teach mathematics.</b> <i>Default 4</i></p>	1	2	3	4	5
<p>8. <b>The instructional strategies were consistent with investigative mathematics.</b> <i>Note- compared with some items above this is less about overall lesson structure/design and more about implementation. Does teacher get students interested and prepared to do an investigation or problem? Does she “let go” enough -- guiding without telling kids exactly what to think or do? If there is no “letting go” or investigation, are there at least elements of more of an investigative stance – e.g., not just teacher lecture, but some questioning? (E.g., rate 1 if teacher reads from book or simply lectures. Rate 2 if some teacher questioning but little else in the way of investigative mathematics.)</i></p>	1	2	3	4	5
<p>9. <b>The teacher’s questioning strategies for eliciting student thinking promoted discourse around important concepts in mathematics.</b> <i>(To rate 3 or more, teachers must go beyond IRE, and ask questions that probe “why?” No or very few questions (all low-level) with brief student responses= 1. Frequent use of low-level IRE questioning and/or students invited to share some of their ideas related to math (but with little follow-up or in-depth discussion) =2).</i></p>	1	2	3	4	5

Table A1 (Cont.)

<p>10. <b>The pace of the lesson was appropriate for the developmental level/needs of the students and the purpose of the lesson.</b> <i>(e.g., Teacher paid attention to whether students “got it” and adapted pace accordingly. Default 4 and adjust from there).</i></p>	1	2	3	4	5
<p>11. <b>The teacher was flexible and able to take advantage of “teachable moments,”</b> <i>(Including building from students’ ideas – both mathematical and non-mathematical). Default 4</i></p>	1	2	3	4	5
<p>12. <b>The teacher’s classroom management style/strategies enhanced the quality of the lesson.</b> <i>(Smooth, no major interruptions, positive climate with established rules that are followed consistently, students are so engaged that they want to pay attention without prompting gets a 5 – Default 4 for minor but no major problems, teacher does what is reasonable to get students on track, lesson carries on as intended. (3 might be most common rating though – consistent (10 or more) distracting management issues that teacher usually deals with reasonably but are clearly detracting from learning for many kids), kids clearly uninterested in the lesson but are generally doing what they’re told).</i></p>	1	2	3	4	5
<p>13. <b>The vast majority of the students were engaged in the lesson and remained on task.</b> <i>(12 is about the teacher, and this is about the majority of kids. In an extreme case, if the teacher is struggling to deal effectively with a few disruptive kids throughout the lesson but all other kids remain on task remarkably well, you could rate 12 a 2 but 13 a 4. Rate 5 if virtually all are enthusiastically participating. Rate 4 if all on task but not enthusiastically participating or if most are generally enthusiastically on task.)</i></p>	1	2	3	4	5

Table A1 (Cont.)

14. <b>Appropriate connections were made to other areas of mathematics, to other disciplines, and/or to real-world contexts.</b> <i>(Look for several substantive connections to both real world and to other math topics (or other disciplines) to merit 5. Only 1 brief mention of just one of the three areas merits a 2.)</i>	1	2	3	4	5
15. <b>The mathematics taught was precise and free from errors.</b> <i>If unusual attention to mathematical correctness and precision, rate 5. Default 4 for typical classroom instruction with no substantive errors but some lack of mathematical precision. If 1-2 marginal errors, rate 3. If 1 major, substantive errors or 3 marginal errors, rate 2. If more than 2 substantive errors or 4 marginal errors, rate 1. (Note: a marginal error can consist of an error of omission – e.g., a clear, missed opportunity to push kids’ mathematical thinking toward the goal of the lesson, revealing a lack of mathematical awareness on the part of the teacher.</i>	1	2	3	4	5
16. <b>The instructional strategies and activities reflected attention to issues of access, equity, and diversity for students.</b> <i>Default 5</i>	1	2	3	4	5
17. <b>Formal assessments of students were consistent with investigative mathematics.</b> <i>Default 5</i>	1	2	3	4	5
18. <b>Design for future instruction takes into account what transpired in the lesson.</b> <i>Default 5</i>	1	2	3	4	5
19. <b>The instructional strategies and activities respected students’ prior knowledge and the preconceptions inherent therein.</b> <i>Default. 5</i>	1	2	3	4	5
20. <b>The lesson was designed to engage students as members of a learning community.</b> <i>Default 5</i>	1	2	3	4	5

Table A1 (Cont.)

21. <b>In this lesson, student exploration preceded formal presentation.</b> Default 4 or 5	1	2	3	4	5
22. <b>This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.</b> Default 5	1	2	3	4	5
23. <b>The focus and direction of the lesson was often determined by ideas originating with students.</b> Default 4 or 5.	1	2	3	4	5

**B. Mathematical Discourse and Sense-making** (Adapted from OMLI. However, I moved the questions around to fit the flow of the information I was looking for from the observed classes. I added two more questions 11 and 12, which make teacher the focus of observation)

*NOTE: For those below, a “5” might look like 6-10 instances spread among 4 or more students in whole group discussion (particularly if many other hands up and most of the time in the lesson centers around student contributions), as well as most students doing this regularly in small group discussions. If much time devoted to individual seat time that is silent but 6-10 instances in whole-group, then give 4.*

Table A2

*Mathematical Discourse and Sense-making*

1. <b>Student asked questions to clarify their understanding of mathematical ideas or procedures.</b> ( <i>Logistical questions – “may I sharpen my pencil?” don’t count.</i> )	1	2	3	4	5
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Table A2 (Cont.)

<p>2. <b>Students shared their thoughts, observations or predictions.</b> <i>(Plain observations or answers to teachers' questions without explanations are sufficient (e.g., "I think the spinner will land on a 3." Or "It rained yesterday." Or "The answer is 12".) For this item especially, look at whether students consistently attempt to participate (lots of hands up) and how widespread participation is. Unlike items below that require more depth and time for kids' contributions, at least half of the class should be doing this for a 4 or 5 rating.)</i></p>	1	2	3	4	5
<p>3. <b>Students explained mathematical ideas and/or procedures.</b> <i>Students explain "what" they did or "how" they came to an answer – not necessarily "why" it makes sense. Explanation might not be sensible or of high quality.</i></p>	1	2	3	4	5
<p>4. <b>Students justified mathematical ideas and/or procedures.</b> <i>Students explain "why" their answer/solution/idea makes sense, they explain without necessarily being challenged. This question refers to the quality of their explanation.</i></p>	1	2	3	4	5
<p>5. <b>Students listened intently and actively to the thoughts, ideas and/or procedures of others for the purpose of understanding someone's methods or reasoning.</b> <i>You should see students actively listening and referring to each others' ideas to get a 4 or 5. Default 3 for generally quiet, on-task listening but no evidence that they understand or care about each others' ideas.</i></p>	1	2	3	4	5
<p>6. <b>Students challenged each other's and their own ideas that did not seem valid.</b> <i>This can also apply to students challenging the teacher's ideas.</i></p>	1	2	3	4	5

Table A2 (Cont.)

<p><b>7. Students defended their mathematical ideas and/or procedures.</b> <i>Students explain “why” they got an answer when they’re challenged to do so – either by another student or teacher.</i></p>	1	2	3	4	5
<p><b>8. Students determine the correctness/sensibility of an idea and/or procedure based on the reasoning presented.</b> <i>Look for evidence that students and the teacher are looking to student reasoning to determine what is “correct” versus the book or the teacher simply stating what is right.</i></p>	1	2	3	4	5
<p><b>9. Students made generalizations, or made generalized conjectures regarding mathematical ideas and procedures.</b> <i>E.g., they work from examples like <math>4 + 2 = 6</math> and eventually generalize to “even + even = even.”</i></p>	1	2	3	4	5
<p><b>10. Students drew upon a variety of methods (verbal, visual, numerical, algebraic, graphical, etc.) to represent and communicate their mathematical ideas and/or procedures.</b> <i>(If 2 or more representations/tools are used consistently by students to represent/communicate their thinking, rate as 4. If teacher/text demonstrates with various representations and students talk about those, default 3.</i></p>	1	2	3	4	5
<p><b>11. The teacher and students engaged in meaning making at the end of the activity/instruction. (There was a synthesis or discussion about what was intended to be learned from doing the activity.)</b> <i>Quality matters here.</i></p>	1	2	3	4	5

Table A2 (Cont.)

<p><b>12. The teacher productively probed/“pushed on” the mathematics in students’ responses (including both correct and incorrect responses).</b></p> <p><i>If teacher simply validates right answers (e.g., “ok”) and ignores or corrects wrong answers herself, then 1. If teacher re-asked question(s) to get student(s) to correct their own thinking or to check their answer, then 2 or 3. If teacher probed deeper than simply getting a correct answer to the original question – e.g., probed the original misconception or pushed a general idea that was raised by students’ responses, then 4 or 5.</i></p>	1	2	3	4	5
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**C. Task Implementation** (“Task” can be interpreted broadly to include teacher questions posed, reading from the text, etc. It’s what students are being asked to do).

(Adapted from OMLI)

Table A3

*Task Implementation*

<p><b>1. Tasks focused on understanding of important and relevant mathematical concepts, processes, and relationships.</b> <i>(Not just a bunch of repetitive problems, not activity for activity sake, not “expensive tasks” that involve much cutting and coloring but little math – look for tasks that push kids to think hard about mathematical ideas.) Task needs to focus on developing kids’ <u>understanding</u> in order to rate highly.</i></p>	1	2	3	4	5
<p><b>2. Tasks stimulated complex, nonalgorithmic thinking.</b> <i>(Students need to think to figure out how to solve the problem – not apply a routine procedure.)</i></p>	1	2	3	4	5

Table A3 (Cont.)

<p>3. <b>Tasks successfully created mathematically productive disequilibrium among students.</b> <i>(Tasks challenged common misconceptions.)</i></p>	1	2	3	4	5
<p>4. <b>Tasks encouraged students to search for multiple solution strategies and to recognize task constraints that may limit solution possibilities.</b> <i>Default 5</i></p>	1	2	3	4	5
<p>5. <b>Tasks encouraged students to employ multiple representation and tools to support their learning, ideas and/or procedures.</b> <i>(If 2 or more representations/tools (e.g., base-10 blocks, graph paper, flowers, etc.) are used actively and consistently, rate as 4. “Support” can be interpreted as “carry out” – e.g. students use tools to solve problems, do experiments.) If students watched a video and looked at a diagram in a book, I gave 2 because very passive use – not really “employing” the representations.</i></p>	1	2	3	4	5
<p>6. <b>Tasks encouraged students to think beyond the immediate problem and make connections to other related mathematical concepts.</b> <i>Default 5</i></p>	1	2	3	4	5

## D. Classroom Culture (Adapted from LSC and RTOP)

### D1. Ratings of Key indicators

Table A4

#### *Classroom Culture*

<p><b>1. Active participation of all students was encouraged and valued.</b></p> <p><i>Look for teacher involving/calling on a broad range of kids. If most kids involved and contributed in some way, then 4 or 5. For this one, brief answers are fine.</i></p>	1	2	3	4	5
<p><b>2. The teacher displayed respect for students' ideas, questions, and contribution.</b> <i>Look for evidence that student ideas are taken seriously and probed. If student responses are not criticized but tend to consist of 1-word answers and teachers do not follow up or probe further, default 3. Teacher regularly drawing out students' ideas, showing interest in them, trying to understand them, building upon them would be a 5. (Note that these interactions might or might not center around math ideas--this is different than #7 below)</i></p>	1	2	3	4	5
<p><b>3. Interactions reflected a productive working relationship among students.</b> <i>If negative interactions, rate 1. If no interaction at all but no negativity, default 2.</i></p>	1	2	3	4	5
<p><b>4. Interactions reflected a collaborative working relationship between the teacher and the students.</b> <i>(Authority must be shared to get a 4 or 5). If no shared authority but collegial, positive environment then 3. If no shared authority and tense, unenthusiastic or unhappy environment, then 1 or 2.</i></p>	1	2	3	4	5

Table A4 (Cont.)

<p><b>5. Wrong answers were treated as worthwhile learning opportunities.</b></p> <p><i>Teacher uses wrong answers as “teachable moments” and probes the key underlying misconceptions or ideas. If this occurs several times, then 4-5, if at least once, then 3. If teacher prompts student(s) to rethink and correct their wrong answers, then 2 or 3 (depending on consistency and depth of teacher prompts). If wrong answers are simply ignored or corrected by the teacher, then 1.</i></p>	1	2	3	4	5
<p><b>6. Students were willing to openly discuss their thinking and reasoning.</b></p> <p><i>(Both thinking and reasoning to get a 4.) If lots of hands up but brief, 1-word answers, default 3.</i></p>	1	2	3	4	5
<p><b>7. The classroom climate encouraged students to engage in mathematical discourse.</b> <i>This is different from a warm, welcoming climate. Is there really discourse- exchanging of ideas and analyzing/discussing those ideas?</i></p>	1	2	3	4	5
<p><b>8. The teacher was able to “read” the students’ level of understanding and adjusted instruction accordingly.</b> <i>Default 5</i></p>	1	2	3	4	5
<p><b>9. The lesson was modified as needed based on teacher questioning or other student assessment.</b> <i>Default 5</i></p>	1	2	3	4	5
<p><b>10. In general the teacher was patient with students.</b> <i>Default 5</i></p>	1	2	3	4	5
<p><b>11. The metaphor “teacher as listener” was very characteristic of this classroom.</b> <i>Default 5</i></p>	1	2	3	4	5

## **D2. Respect for Diversity**

Based on the culture of a classroom, observers are generally able to make inferences about the extent to which there is an appreciation of diversity among students (e.g., their gender, race/ethnicity, and/or cultural background). While direct evidence that reflects particular sensitivity or insensitivity toward diversity is not often observed, we would like you to document any examples you do see. If any examples were observed, please check here \_\_\_ and describe below:

*Appendix B*

*Interview Protocol*

Table B1

*Pre-observation Interview*

Note: This protocol was used with each of the three mathematics teachers at each of the three participating schools. The interview was executed before each classroom observation. The purpose of the pre-observation interview was to gain information about the context of the lesson before it started.

1. What has this class been covering recently?  
What unit are you working on?  
What instructional materials are you using?
2. What do you anticipate doing with this class today?  
What would you like the students to learn during this class?
3. Is there anything in particular that I should know about the students in this class?

Table B2

*Gender Gap*

Note: This protocol was used with each of the three mathematics teachers at each of the three participating schools. The interview was executed the first day of data collection after the first observation of classroom lessons. The purpose of the interview was to better understand the teachers' teaching experiences, and their understanding of the gender gap.

**Introductory Remarks:** Good morning (Good afternoon). My name is.... What is your name? Thank you for taking the time to talk with me today. This interview will probably take 45-50 minutes to complete. To facilitate my note taking, I would like to audio tape our conversations today. Please sign the release form (Give the interviewee some minutes to sign the release form). For your information, only my advisor and I will be privy to the audio-recorded materials, which will eventually be destroyed after they are transcribed. This interview will only be used for the purpose of my dissertation research with the title “Exploring the Gender Gap in Tanzania Secondary Mathematics Classrooms” and will be kept confidential. I will not identify you by name in the report or in any conversations with other people. In addition, you must sign a form devised to meet our human subject requirements. Essentially, this document states that: (1) all information will be held confidential, (2) your participation is voluntary and you may stop at any time if you feel uncomfortable, and (3) I do not intend to inflict any harm. Thank you again for your agreeing to participate.

1. Please share with me a little background information about yourself: What classroom level(s) do you teach? How long have you been teaching this/these classrooms? How long have you been teaching in this secondary school?
2. Have you always worked in schools with similar demographic as this one?
3. Where are you from originally/where did you grow up? Where did you go for secondary education? College/university studies?
4. What made you decide to become a teacher?
5. What has your overall experience been like working at ... secondary school?
6. What has your experience been like working with coeducational classes?
7. Have you ever worked with single-gender classes? If yes, what was your experience? Where were the differences between the groups, if any?
8. How would you compare the academic performance of male and female students?

9. Research shows that there is gender gap in secondary school mathematics achievement.

Why do you think there is gender gap?

10. What kinds of role models do you find your students looking up to?

11. How do the students influence each other with schoolwork?

12. Do you see any other factors influencing the students' work?

13. Does the mathematics Department/your School make a conscious effort to help girls improve mathematics learning? If yes please provide examples, if no, tell me the best ways to help girls learn mathematics.

14. If there were anything that you could change to raise the performance level of your students, what would it be?

15. Is there anything else you would like to tell me about mathematics achievement gender gap? Any concerns you have?

***Thank you so much for taking your time for this interview and for all you have shared with me.***

Table B3

*Problem Solving Approach*

<p>Note: This protocol was used with each of the three mathematics teachers at each of the three participating schools. The interview followed my second classroom observation. The purpose of the interview was to understand the teachers' understanding of their teaching within a problem solving approach and formative assessment practices framework.</p>
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**Introductory Remarks:** Thank you for taking the time to talk with me today. This interview will probably take 45-50 minutes to complete. As I mentioned to you before, I am doing these interviews with two other mathematics teachers from two different secondary schools. The information from these interviews will be pulled together, analyzed and a report will be written for the purpose of my dissertation research with the title “Exploring the Gender Gap in Tanzanian Secondary Mathematics Classrooms.” This interview will be used for this purpose only and will be confidential. (I will not identify you by name in the report or in any conversations with other people.)

1. Most teachers would say that they want their students to understand mathematics. Are you one of them? If yes, how do you know that a student understands how to add 35 and 47? If no why not? (Teaching for understanding)
2. Learning computational skills and developing conceptual understanding are frequently seen as competing objectives. In other words if you emphasize understanding, then skills suffer. If you focus on developing skills, then understanding suffers. Do you agree with this analysis? If yes, why and if no why not? (Teaching for understanding)
3. What kind of mathematics tasks do you give your students? (Nature of classroom tasks)
4. What do you normally do to facilitate conceptual understanding? (The role of the teacher)
5. How do your students interact about mathematics? (Social culture of the classroom)
  - How do you react to student’s ideas/answer?
  - Do you give your students opportunities to share their answers with their peers?
  - How do you and your students see mistakes? What do you normally do when a student makes mistakes?
  - Are you surprised when a very weak student (a girl you know is weak in classroom) gives a persuasive explanation or correct solution? If yes, why, and if no, why not?

6. What physical materials do you normally use to teach mathematics? How do you use different mathematical tools? For what purpose? (Mathematical tools as learning supports)
7. Teachers who use a PSA believe that every student has the right to reflect on, and communicate about, mathematics. How do you give equitable opportunities for all students in your classroom? (Equity and accessibility).
8. What is the importance of culture and individuality in the classroom? How do you account for and utilize them to benefit students?
9. So far we have been discussing the features of a problem solving approach in teaching mathematics. How do problem solving approach lessons work in co-education classrooms? Do they acknowledge or maximize gender differences/similarities? In what ways?
10. What is the purpose of lesson design? How do you connect lesson design and classroom management/environment? Do problem solving approach lessons alter your classroom management? In what ways?
11. How do you conduct assessments for problem solving approach lessons?
12. Tell me about your understanding of formative assessment in the teaching of mathematics. What makes an assessment formative?
13. What is the role of peer collaboration/group work in problem solving approach lessons? Is the role the same in formative assessment practices?
14. What types of teaching and learning tools do you use with students in mathematics classes? How do you define a teaching/learning tool?

15. How do you focus students in their own learning styles/skills? In what ways do you teach them about “how they learn” and how to take responsibility of their learning?

*Thank you so much for taking your time for this interview and for all you have shared with me.*

Table B4

*Formative Assessment Practices*

Note: This protocol was used with each of the three mathematics teachers at each of the three participating schools. The interview followed my third classroom observation. The purpose of the interview was to make a follow up of the teachers’ understanding of their teaching within a problem solving approach and formative assessment frameworks.

**Introductory Remarks:** Thank you for taking the time to talk with me today. This interview will probably take 25-30 minutes to complete. As I mentioned to you before, I am doing these interviews with two other mathematics teachers from two different secondary schools. The information from these interviews will be pulled together, analyzed and a report will be written for the purpose of my dissertation research with the title “Exploring the Gender Gap in Tanzania Secondary Mathematics Classrooms.” This interview will be used for this purpose only and will be confidential. (I will not identify you by name in the report or in any conversations with other people.)

1. What have been your biggest challenges in teaching mathematics this year?
2. How do you go about assessing whether students grasp the material you present in class?

Probe: Do you use evidence of student learning in your assessment of classroom

strategies?

3. What kinds of assessment techniques tell you the most about what students are learning?  
Probe: What kinds of assessment most accurately capture what students are learning?
4. What ways do you typically use to identify your student strengths and areas of difficulties in math?
5. Do you use the mistakes your students make when they answer questions in class? If yes, how? If no why not?
6. Do the National examination results help you reflect about your students' progress over the course of the entire year? If so, how? If not, why not?
7. Has looking at the National examination results led you to rethink anything about the way you teach? In what ways?
8. Would your teaching be different without National examinations? If so, how?
9. How is the assessment of student learning used to improve teaching/learning in your department? ... On campus?
10. Describe how teaching, learning, and assessment practices are improving on this campus  
Probe: How do you know? (Criteria, evidence)
11. Is the assessment of teaching and learning a major focus of attention and discussion here?  
Probe: Why or why not? (Reasons, influences)
12. What specific new teaching or assessment practices have you implemented in your classes?

***Thank you so much for taking your time for this interview and for all you have shared with me.***

*Appendix C*

*Codes for Teacher's Instructional Practices*

Table C1

Code	Explanation
Designing a lesson—DL	The teacher structured the lesson so that most students did at least one of the following: sustain a focus on a topic for a significant period of time; demonstrate their understanding of the problematic nature of a mathematical concept; arrive at a reasoned, supported conclusion with respect to a complex mathematical concept; or explain how they solved a problem.
Implementing a lesson—IL	The teacher supported the students by conveying high expectations, challenging work, strong effort, mutual respect, and assistance for all students.
Respecting Diversity—RD	The teacher respected the students' gender differences and their background.
Monitoring student learning—MSL	A teacher provides ongoing feedback, which he uses to improve his teaching and the students use the feedback to improve their learning.
Teaching through problem solving—TPS	Task implementation: The teacher gives students the work to do that helps them to engage in the lesson. For instance, attentiveness, doing the assigned work, showing enthusiasm for work by taking initiative to raise questions, contributing to group tasks, and helping peers.
Questioning—Q	A student asks a question to clarify his or her understanding of a mathematical idea or procedure.
Answering—A	A student gives a short answer to a direct question from the teacher or another student.

Table C1 (Cont.)

<p>Making a Statement or Sharing—MS</p>	<p>A student makes a simple statement or assertion, or shares his or her work with others and the statement or sharing does not involve an explanation of how or why. For example, a student reads what she wrote in her journal to the class.</p>
<p>Justifying—J</p>	<p>A student provides a justification for the validity of a mathematical idea or procedure by providing an explanation of the thinking that led him or her to the idea or procedure. The justification may be in defense of the idea challenged by the teacher or another student.</p>
<p>Listening—L</p>	<p>A teacher uses what students know to construct further understanding. The teacher may indeed talk a lot, but such talk is carefully crafted around understandings reached by actively listening to what students are saying. Teacher as listener is fully in place if student as listener is reciprocally engendered.</p>
<p>Challenging—C</p>	<p>A student makes a statement or asks a question in a way that challenges the validity of a mathematical idea or procedure. The statement may include a counter example. A challenge requires someone else to reevaluate his or her thinking.</p>
<p>Explaining—E</p>	<p>A student explains a mathematical idea or procedure by stating a description of what he or she did, or how he or she solved a problem, but the explanation does not provide any justification of the validity of the ideas or procedure.</p>
<p>Predicting or Conjecturing—P</p>	<p>A student makes a prediction or a conjecture based on their understanding of the mathematics behind the problem. For example, a student may recognize a pattern in a sequence of numbers or make a prediction about what might come next in the sequence or state a hypothesis a mathematical property they observe in the problems.</p>

Table C1 (Cont.)

Generalizing— G	A student makes a statement that is evident of a shift from a specific example to the general case.
Relating—R	A student makes a statement indicating that he or she has made a connection or sees a relationship to some prior knowledge or experience.