Science and Mathematics Education Centre

Reforming Mathematics Education in Indonesia Using the Productive Pedagogies Framework

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DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief, this thesis contains no material previously published by any person except where due acknowledgement has been made.

Signature: 

Suhendra

Date: April 9, 2015

DEDICATION

In the name of Allah, the Most Beneficent, the most Merciful

This thesis is dedicated to my beloved late father and mother who supported me wholeheartedly through their unconditional love and prayers from the very beginning of my studies, when they were alive, until their death.

This thesis is also dedicated to my wife, Leny, who has never left my side and has been a great source of love, motivation and encouragement; my wonderful sons, Fachreza and Fadhilah, for their love, inspiration and support; my parents in-law for their support and patience as they have waited for my journey to be complete; my brothers, sisters and relatives who have supported me throughout the study.

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ABSTRACT

Mathematics is often perceived as a difficult subject with many students failing to understand why they need to learn the subject. In Indonesia, this situation has been further aggravated by the teaching and learning processes used, which are largely teacher-oriented and mechanistic with a focus on drill. As such, the teaching of mathematics has relied on the transfer of information from the teachers to their students and the introduction of abstract concepts and formulae without due attention to logic, reasoning, or understanding.

The reform of education, including mathematics, has been placed high on the Indonesian government's agenda. To date, however, the changes in classroom practices, as with other countries around the world, have been limited. This study examined, on a small scale, the usefulness of implementing the Productive Pedagogies framework as a means of improving the quality of mathematics teaching in Indonesia.

The research subjects included four teacher-participants, two from a rural school and two from an urban school, and their mathematics classes. The study used action research as the research methodology because of its overarching characteristics. The teachers implemented and evaluated their use of the Productive Pedagogies framework over three action research cycles. Throughout the action research cycles, data were collected using multiple research methods that included classroom observations, focus-group and in-depth interviews, teachers' reflective journals and theresearcher's journals. Analysis and interpretation of the data were carried out throughout the study and commenced while the data were being collected.

The findings of the study indicated that there were a number of challengesrelated to the implementation of the various elements of the Productive Pedagogies framework including difficulty inchanging teachers' mindset from the old to the new teaching paradigm (the framework) andthe level of understanding of the framework.

Throughout the action research cycles, the teachers used the elements of the framework to reflect on their teaching. First, the teachers were required to use the Productive Pedagogies framework to develop lesson plans. These lesson plans then could be used by teachers to determine the extent to which the objectives were achieved and, importantly, the effectiveness of the teaching strategies used to achieve them. The findings indicated that, by using the twenty elements in the planning and reflection of lessons, teachers were provided with a comprehensive guide that they could draw on to make decisions about how they could improve their lessons.

Finally, the effectiveness of using the Productive Pedagogies was examined in terms of improved classroom interactions, connectedness of mathematics and enhanced social justice. In all cases, the changes made in the mathematics classrooms, brought about by the implementation of the Productive Pedagogies framework, made significant differences to the teaching and learning processes. The improved interactions among students and between the teachers and the students meant that students became more involved in the teaching learning process. Using the Productive Pedagogies framework helped teachers to make mathematics more relevant to students, by including students' prior knowledge, connecting the lessons with other topics, integrating other subjects into the lessons and providing sufficient relevant illustrations. This increased relevance would appear to have increased

students' engagement in the teaching and learning process. Importantly, these changes made by the teachers as they implemented the Productive Pedagogies framework led to classrooms in which social justice was enhanced, with mathematics learning becoming more accessible to all students.

Finally, the changes made in the mathematics classes led to greater engagement of the students. The students became more enthusiastic to attend their mathematics classes and displayed more on-task and engaged behaviours during the learning activities.

As the first study in Indonesia to examine the introduction of the Productive Pedagogies framework, my study adds to the literature. The findings also have the potential to make a contribution to those seeking to reform mathematics teaching in Indonesia. The success of the four teachers, by applying the Productive Pedagogies framework, has demonstrated its overall usefulness and provided lessons from which further use of the framework might build upon. Although undertaken on only a small scale, the results could inform policy makers and professional development providers about how the Productive Pedagogies framework might contribute to the reform process.

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1.1 Introduction

There is broad consensus among policy makers, curriculum planners, school administrators and business and industry leaders that mathematics is an important element of the school curriculum. The importance of mathematics is implicitly accepted by governments around the world through the emphasis placed on monitoring school improvement in terms of mathematics outcomes (Sullivan, 2011). Further, Mathematical proficiency has been identified as one of the key competencies necessary for personal fulfilment, active citizenship, social inclusion and employability in the knowledge society (Parveva, Naoorani, Ranguelor, Motiejunaite & Kerpanova, 2011). Mathematics competence enhances students' abilities to communicate and negotiate meanings (Fuatai, 2010).

Despite the importance of mathematics to the lives of students, mathematics teaching and learning continues to be an area of concern around the world, with the Republic of Indonesia (hereafter referred to as Indonesia) being no exception. It is well documented that many students struggle with mathematics and, as a result, become disaffected. Much research has suggested that mathematics education continues to be fundamentally disconnected from learners' lives and irrelevant to their needs (Schmidt, 2011). According to Parveva et al. (2011), mathematics, both at school and within the wider community, is often perceived as difficult and abstract, involving a significant number of processes and formulae that appear disconnected with each

other. It is important, therefore, that we understand what effective mathematics teaching looks like (Anthony & Walshaw, 2007). To this end, past research in the field of mathematics education has sought to distil important aspects of teaching and learning, including the specific ways in which quality teaching operates, the degree to which teaching drives learning, and how effectiveness evolves as teachers' progress (Hightower, Delgado, Lloyd, Wittenstein, Sellaers & Swanson, 2011).

In Indonesia, at the time of writing this thesis, the teaching and learning of mathematics was largely teacher-oriented, with a focus on drill and was, for the most part, mechanistic, with teachers dictating formulas and procedures to their students (Hadi, 2002). These pedagogical approaches tend to lead to classrooms in which students play a passive role and are viewed, by the teacher, as objects of teaching (Armanto, 2001; Dahlan, 2004). In the majority of mathematics classes, in Indonesia, mathematics teaching relies on the transfer of information from the teacher to his or her students. There is, however, a growing awareness of the need to improve mathematics teaching in schools (Sembiring, Hadi & Dolk, 2008) and, according to Zamroni (2000), one of the biggest concerns raised by mathematics teachers in Indonesia is the need to make mathematics lessons more relevant to their students' needs.

Given these ongoing issues, the present study sought to examine a means of overcoming some of the problems that Indonesia is experiencing in high school mathematics classes. It was anticipated that, implementing the productive Pedagogies framework might help to improve the quality of teaching and student engagement. Therefore, the overarching aim of the research reported in this thesis was to develop,

implement and evaluate the use of the Productive Pedagogies framework to improve students' mathematical knowledge and engagement. As such, this chapter describes the context (Section 1.2) and background to the study (Section 1.3) and provides a brief description of the Productive Pedagogies framework(Section 1.4). The chapter goes on to outline the objectives of the study (Section 1.5), the significance of the research (Section 1.6), and finished by providing an overview of the thesis (Section 1.7).

1.2 Context of the Study

This section provides information related to Indonesia and the current reform that is taking place (Section 1.2.1) and a background to the study, with specific reference to the current state of mathematics education in Indonesia (1.2.2).

Indonesia is situated in Southeast Asia and is made up of 18,108 islands spread over 3,400 miles along the Equator. The largest of these islands are Sumatra, Java, Bali, Kalimantan and Sulawesi. Indonesia is a republic with a presidential system. As a unitary state, power is concentrated in the central government. The president of Indonesia is the head of state and head of government, commander-in-chief of the Indonesian National Armed Forces, and the director of domestic governance, policy-making, and foreign affairs.

The country is made up of 34 provinces, each of which has its own legislature and governor. Five of the 34 provinces have special status, these being, Aceh, Jakarta, Yogyakarta, Papua, and West Papua. These five provinces have greater legislative

privileges and a higher degree of autonomy from the central government than the other provinces. For example, the Acehnese government has the right to create certain elements of an independent legal system. Yogyakarta was granted the status of Special Region in recognition of its pivotal role in supporting Indonesian Republicans during the Indonesian Revolution and its willingness to join Indonesia as a republic. Papua was another province with a higher degree of autonomy from the central government.

The provinces of Indonesia are further subdivided into regencies (*kabupaten*) and cities (*kota*), which are further subdivided into districts (*kecamatan* or *distrik* in Papua and West Papua), and again into administrative villages (either *desa*, *kelurahan*, *kampung*, *nagari* in West Sumatra, or *gampong* in Aceh). The village is the lowest level of government administration in Indonesia, which is divided into community groups (*Rukun Warga - RW*) that are further divided into neighbourhood groups (*Rukun Tetangga*). In Java the *desa* (village) is divided further into smaller units called *dusun* or *dukuh* (hamlets), these units are the same as Rukun Warga. The regencies and cities have become the key administrative units that are responsible for providing most government services. The village administration level is the most influential on a citizen's daily life and handles matters of a village or neighborhood through an elected *lurah* or *kepala desa* (village chief).

At 1,919,440 square kilometres, Indonesia is the world's 15th-largest country in terms of land area and the world's seventh-largest country in terms of combined sea and land area. Its population density is 79th in the world, with an average of 134 people per square kilometer. Among the islands of Indonesia, Java is the world's

most populous island, with a density of 940 people per square kilometer (Wikipedia, 2014).

The closest countries to Indonesia are Malaysia, East Timor, and Papua New Guinea which share land borders with Indonesia. Other neighbouring countries are Australia to the south, Singapore to the Northwest, and Philippines to the Northeast. Figure 1.1 below shows a map of Indonesia in relation to other countries.

Figure 1.1 Map of Indonesia

The national motto of Indonesiais, *Bhinneka Tunggal Ika* [unity in diversity], serves to articulate the diversity that shapes the country. As the fourth most populous country in the world (with a population of approximately 246 million people), Indonesia boasts a total of 737 languages spoken throughout the country, many of which are confined to remote tribal groups. Added to this diversity, the population of

Indonesia is made up of more than 300 distinct native ethnic and linguistic groups. Despite the diversity of this republic, a shared identity has developed; defined by a national language (Bahasa Indonesia), ethnic diversity, religious pluralism within a majority Muslim population, and a history of colonialism and the country's rebellion against it.

The official philosophical foundation, that forms the basis of the 1945 Constitution of the Republic of Indonesia, is known as *Pancasila*, or the Five Principles. The Five Principles was formulated by the, then, Indonesian nationalist leader who later became the first president of Indonesia, Soekarno. On June 1, 1945, in a speech to the preparatory committee for Indonesia's independence, Sukarno argued that the future of Indonesian should be based on the Five Principles, these being, the belief in one God, just and civilized humanity, Indonesian unity, democracy under the wise guidance of representative consultations and social justice for all the peoples of Indonesia (Britannica, 2013). The Five Principles have since become a blueprint for the Indonesian nation and has been referred to as one of the guidelines in determining all of Indonesia's national visions. As a result, the national education system of Indonesia is rooted in the Five Principles, as well as the religious values and national cultures of Indonesia (Depdiknas, 2003b).

In the 1990s, the Indonesian government embarked on a major reform of its educational system that focused on improving the quality of the compulsory level of education (six years of primary and three years of secondary education) that included all citizens between the age of seven and fifteen years. The rationale for focusing on compulsory education was that, in spite of large population and extensive natural

resources, Indonesia's education system was not highly developed. The aim of the reform was to ensure that all students had equal and ample opportunities to receive formal schooling (Depdiknas, 2003b).

According to the Act of the Republic of Indonesia Number 20, 2003, education is defined as a conscious and well-planned effort to create a suitable learning environment and provide appropriate learning processes that will optimise learning outcomes. Further, the act states that the national education system functions to develop the capability, character and civilisation of the nation by enhancing intellectual capacity and developing learner's potentials so that they are imbued with human values leading them to be faithful, pious and possess noble character. The education system serves to develop the potential of learners to ensure wealth, knowledge, competence, creativity and independence.

The Act of the Republic of Indonesia Number 20, 2003, Article 3 of the act stipulates that the function of national education is to develop and establish the character of the nation's dignity and should be aimed at developing the potential of learners in order that they become a person of faith with fear of the Almighty God, and one who is moral, healthy, knowledgeable, capable, creative, independent, and accountable (Depdiknas, 2003b).

The Act of the Republic of Indonesia Number 20, 2003 (Depdiknas, 2003a) also stipulates that education in Indonesia is divided into two major sectors, formal and non-formal. Non-formal education is a substitute program designed to eradicate illiteracy in the Indonesian language. Formal education consists of three levels: basic education, secondary education and higher education. Under the regulation of both

ministries, all Indonesia citizens must undertake nine years of compulsory education which consists of six years at elementary level and three years at the secondary level.

Unlike many countries around the world, the education system of Indonesia is the responsibility of two institutions, the Ministry of Education and Culture and the Ministry of Religious Affairs. Public secular schools and non-Islamic private schools fall under the administration of the Ministry of National Education and Culture, while Islamic schools are administered by the Ministry of Religious Affairs.

The national education goal stipulates the quality of Indonesia's human resources to be developed by educational units. Further, each educational unit has the responsibility to provide quality education as mandated by national education system of Indonesia which states that education serves to develop and shape the character and civilization of the nation. This normative national education goals need to be elaborated and implemented in the quality teaching and learning process of all subject, of which mathematics is no exception.

The reform effort has continued into the turn of the century. Prior to 1999, the Indonesian education system was highly centralised with all decisions related to course content, selection of textbooks, teaching hours and other matters associated with public school governance being determined by the Ministry of Education (Division of Educational Policies and Strategies UNESCO, 2006). However, after the collapse of the Suharto regime, in 1998, Act Number 22, 1999 (relating to regional governance), was decreed to bring about the decentralisation of the Indonesian

Government. These structural changes were supported by international agencies, such as, the World Bank and Asian Development Bank.

To support the decentralisation within the education sector, two further acts were decreed, namely, Act Number 20, 2003 (known as the *Sistem Pendidikan Nasional* or the National Education System) and Government Regulation Number 19, 2005 (known as the *Standar Nasional Pendidikan* or the National Standard of Education) (Depdiknas, 2005). These two acts were designed to promote the autonomy of the education sector under the direction of local government at the district level. In response to this decentralisation, the education sector adopted a school-based management scheme (Depdiknas, 2003b) in which the central government delegated autonomy, in terms of management, to schools in all areas.

Over the last decade, the Indonesian government has continued to reform education. However, during this era, the focus shifted from school improvement to ensuring that the quality of learning improves students' outcomes. This shift has meant that reform efforts within the education sector are now targeting enhanced performance and providing a more equitable distribution of educational opportunities. These reform efforts have had a fundamental impact on the Indonesian national education system (Depdiknas, 2003b). For example, the teacher law was introduced and the constitutional obligation to spend at least 20 percent of the budget on education sector. As a result of this policy, the teaching profession has become more attractive when compared with other similar jobs, in terms of remuneration, working conditions and job satisfaction. As such, the selection processes for teacher education

ensure that only appropriate individuals are selected for teacher education and that intakes match with teacher needs.

It is within the context of this education reform that was taking place at the time of writing this thesis that the present study sought to examine the impact of using an established framework to improve the quality of teaching and learning in Indonesia. The next section provides the background to this research.

1.3 Background to the Study

Mathematics education has undergone many changes over the past three decades, in terms of the curriculum, assessment and teaching strategies. Despite all of the changes and initiatives, however, it appears that mathematics continues to be a problem for the majority of students, many of whom fail to understand why they need to learn mathematics (Burghes & Robinson, 2010). Past research indicates that mathematics teaching, in its current form, makes it difficult for students to learn and to engage in mathematics, which has resulted in both a lack of understanding of mathematical concepts and a lack of the ability to solve mathematical representations from a contextual problem (Mitchelmore, 1995; NCTM, 2007; Wetzel, 2010).

As mentioned earlier, at the time of writing this thesis, the teaching and learning of mathematics in Indonesia, by and large, involved rote learning, following rules, executing procedures and utilising formulas. These approaches are, for the most part, theoretical, involving the introduction of abstract concepts and formulae without paying much attention to aspects related to logic, reasoning, and understanding

(Soedjadi, 2000). To further aggravate this situation, the teaching and learning process relies on the transfer of information from teachers to their students (Somerset, 1997) which can lead to mathematics teaching that is mechanistic with teachers tending to dictate formulas and procedures to their students. By limiting mathematics teaching to these traditional methods, it is likely that only those students who are capable of absorbing, accumulating and regurgitating received items of information are likely to succeed (Brandy, 1999; Hiebert, 2003).

Despite these traditional teaching methods, there has been some evidence of success in mathematics education in Indonesia. A total of 73 medals have been won by individual students in four international mathematics competitions, including, 13 gold medals, 20 silver medals and 40 bronze medals. The competitions include the 10th International World Youth Mathematics Intercity Competition (held in Durban, South Africa in 2009), the 3rd Wizards at Mathematics International Competition (held in Lucknow, India in 2009), the 6th International Mathematics and Science Olympiad for Primary School 2009 (held in Yogyakarta, Indonesia in 2009) and the International Mathematics Competition (held in Iloilo City, Philippines in 2009). Despite the success of these individual students, however, the average achievement of Indonesia students is below that of their counterparts in neighbouring countries (Hendayana, Supriatna & Imansyah, 2009).

In recognition of the problems related to mathematics education, the Indonesian Government has initiated a large-scale mathematics education reform (Sembiring et al., 2008). The reform is in line with Indonesia's national education mission which involves enhancing the national education system to provide a powerful social

structure and to ensure the development of good quality Indonesian citizens (Yulaelawati, 2002). The reform efforts include elements of equity and justice, fostering a classroom culture that challenges students to move away from their current receptive roles (towards more participatory roles), and to move away from theoretical to applied mathematics. Whilst initiatives aimed at improving mathematics teaching have been implemented across the country, their impact and overall success has been questionable (Sullivan, 2011).

Hendayana et al. (2009) have suggested that the low quality of mathematics education in Indonesia might also be the result of underqualified teachers and a large disparity in teacher quality. As such, they recommended that the government of Indonesia focus on improving teacher quality through qualification upgrading, continuous teacher professional development and placing high priority on teacher recognition. Given that it is the teachers of mathematics who are the key to mathematics education reform, it is important that teachers be well trained and use effective teaching practices (McGraner, Van Der Heyden & Holdheide, 2011). Zulfikar (2009) claims that successful teachers are not simply responsible for transferring knowledge, but they should organise classrooms, implement effective classroom pedagogy and work cooperatively with a diversity of students. It is anticipated that the reform efforts will provide the means through which mathematics teachers will shift their teaching style away from a traditional teaching paradigm towards more progressive models of teaching (from teacher-oriented to student-oriented).

The transition from a traditional paradigm towards a problem-based approach to mathematics education constitutes a complex reform that requires not only the introduction of new instructional methods, but also new social and socio-mathematical norms. To be successful, mathematics teachers in Indonesia will need to become responsible for fostering a classroom culture that challenges students to move towards more participatory roles. The reform efforts will require that schools and teachers work towards generating student interest and engagement and making mathematics teaching more meaningful (Parveva et al., 2011).

To be effective then, mathematics teachers will need to implement new teaching styles that target all students, regardless of their background. The teaching strategies will need to foster positive attitudes and give students the confidence that they need to achieve well and to study mathematics beyond the secondary level. The research reported in this thesis, focused on implementing strategies, using the Productive Pedagogies framework, to improve the quality of mathematics education and to reform the current practices of teachers in Indonesia. Section 1.4 provides an introduction to the Productive Pedagogies framework, which is expanded on later in Chapter 2.

1.4 Productive Pedagogies Framework

The importance of mathematics within society and the current disconnection of mathematics education with the lives of students has resulted in a mathematics education movement that is concerned both with providing equitable access for all students to learn effectively and in helping students to be protagonists, with respect

to changing their world in ways that are more socially just (Ball, 2008). This movement is concerned with the intellectual demand placed on students within the classroom, the relevance of the mathematics taught to their lives outside of school, the level of support provided to students within the learning environment, and the lack of recognition of students' differences. It is anticipated that this movement, with its aim of creating meaningful learning experiences for students, regardless of their background, will result in a significant improvement in the quality and effectiveness of mathematics education. The Productive Pedagogies framework is borne out of this movement and provides a means by which teachers can improve the quality of teaching and learning, in general, and in teaching and learning of mathematics, in particular.

The Productive Pedagogies framework was built upon a large body of research related to the production of socially equitable student learning outcomes (Ladwig, Luke & Lingard, 1999). Through its dimensions, the Productive Pedagogies framework provides a list of characteristics that have been found to be related to effective teaching. The framework has been recognised as a means of creating a learning process that has a positive impact on students' academic and social outcomes.

The Productive Pedagogies framework involves four overarching dimensions, these being: 1) Intellectual Quality; 2) Connectedness; 3) Supportive Classroom Environment; and 4) Recognition of Difference (Mills, Goos, Keddie & Honan, 2009). Each of these four dimensions includes a number of elements (20 in total). As

an introduction to the Productive Pedagogies framework (that is expanded upon in Chapter 2), this section provides an overview of the four dimensions.

The Intellectual Quality dimension is related to a heightened intellectual demand on students and stresses the importance of presenting all students, regardless of their background and perceived academic ability, with intellectually challenging work (Sizer, 1996). There are a number of studies that have shown that students do not achieve their highest academic performance because schools do not always require them to complete work of a high intellectual quality (Hayes, Mills, Christie& Lingard, 2006). Therefore, Zevenbergenand Niesche (2008) purport that, in terms of intellectual quality in mathematics, the tasks should enable and foster deep mathematical learning. To be effective, this dimension demands that challenging activities be incorporated into the teaching process as a matter of priority for all students, especially for those from disadvantaged groups and low socioeconomic backgrounds.

The Intellectual Quality dimension includes six elements, these being, metalanguage (focusing on aspects of language, grammar and technical vocabulary); substantive conversation (focusing on interaction among students and between teacher and students, about the ideas of a fundamental topic); deep knowledge (focusing on establishing relatively complex connections to those central concepts); deep understanding (focusing on encouraging students to grasp the relatively complex relationships between the central concepts of a topic); higher order thinking (focusing on the transformation of information by combining the information to

synthesise, generalise and explain to get conclusions); and knowledge as problematic (focusing on an understanding of knowledge not as a fixed body of information).

The second dimension, Connectedness, is related to connecting learning to students' lives outside of school. This dimension focuses on making classes relevant for students by considering the students' culture and what they already know. The Connectedness dimension designed to accommodate the needs of students, in particular, those who are marginalised or low achieving. This dimension was developed to ensure that students engage with real, practical or hypothetical problems which connect to the world beyond the classroom (Education Queensland, 2001b). It is anticipated that, by incorporating pedagogies that connect classroom learning with the real world will motivate students to engage with the learning process, a link which is often absent when the curriculum is divorced from the lives of students (Hayes et al., 2006). Further, the notion of Connectedness links new knowledge with the students' background knowledge and the world outside of the classroom. As such, this dimension requires teachers to identify and solve intellectual and/or real problems.

The elements related to the Connectedness dimension are: knowledge integration (focusing on connecting two or more sets of subject area knowledge); background knowledge (focusing on connecting between students' background knowledge and experience and the topics, skills and competencies); connectedness to the world (focusing on connecting the lesson and learning activities to competencies or concerns beyond the classroom);and problem-based curriculum (focusing on presenting specific practical, real problems or sets of problems to solve by students).

The third dimension, Supportive Classroom Environment, aims to support the two dimensions introduced previously (Intellectual Quality and Connectedness). This dimension focuses on providing an environment that facilitates intellectual stimulation by developing positive and mutually-supportive relationships within the learning environment. Such relationships break down the power imbalance between teachers and students and are important given that many students are resistant to being overpowered and controlled (Mills, 1997; Martino & Pallotta-Chiarolli, 2003). Past research in the field of learning environments provides strong and convincing evidence that the quality of the learning environment is strongly and consistently related to a range of student outcomes (Fraser, 2012).The elements related to the Supportive Classroom Environment dimension, include: student direction (focusing on providing student opportunities to involve in determining specific learning activities or outcomes); social support (focusing on a learning atmosphere of mutual respect and support between teacher and students and among students); academic engagement (focusing on encouraging students to engage and on-task during the lesson in order to demonstrate academic engagement); explicit quality performance criteria (focusing on explicitly judging the range of student performance at different stages); and self-regulation (focusing on considering the direction of student behaviour implicit and self-regulatory).

The fourth dimension, Recognition of Difference, focuses on the need for inclusive classroom practices that both support and incorporate the diversity of students' backgrounds, experiences and abilities (QSRLS, 1999). The Recognition of Difference dimension is strongly related to issues of social justice and inclusion (Lingard & Mills, 2007). It was with this in mind that, for the purpose of the present

study, this dimension was extended to include a focus on social justice. The presence of this dimension develops student awareness of how various factors, such as, gender, age and socioeconomic status affect their identities (Gutstein, 2003). A focus on this dimension serves to encourage students to expose their understandings and to develop their ability to construct a perception of non-domination or democratic concepts. That is, by providing opportunities for students to actively learn how to become democratic individuals, they are likely to develop an understanding that all students have the right to be treated fairly. Recognition of difference dimension was developed to encourage students to understand their identity as members of a society.

The Recognition of Difference dimension embraces five elements, these being: cultural knowledge (focusing on cultural identity in which there is explicit appreciation of the characteristics); inclusivity (focusing on actively engaging all students from diverse backgrounds);narrative (focusing on the style of teaching that consists of a linked sequence of events and involves an emphasis); group identity (focusing on building a sense of community and identity of students); and active citizenship (focusing on encouraging active citizenship within the classroom).

Given that the Productive Pedagogies framework provides a reasonably comprehensive account and guidelines for effective teaching practice, it was anticipated that such a framework could, potentially, support the development of effective mathematics teaching in Indonesia. The Productive Pedagogies framework does not, however, provide a ready-made technique for teaching but, rather, an approach to creating a place, space and vocabulary for teachers to use in classroom

instruction discourse (Atweh & Brady, 2009). Therefore, in its implementation in the classroom, teachers are required to adapt the dimensions of the framework to be more in line with the 'local' situation.

A key feature of the Productive Pedagogies framework is the principle of social justice, particularly equity and inclusion, as a central element of good practice in schooling. Thus, both Productive Pedagogies and social justice share common concerns about how to encourage the involvement of students as individuals or groups in school activities and their enjoyment of learning benefits, including the quality of the process, equity of opportunities, connectedness of content to the student's life and the student's academic background.

As described earlier, the Indonesian vision is reflected in the Preamble of the 1945 Constitution of the Republic of Indonesia which describes the *Pancasila* (the Five Principles). The present study is line with the Five Principles, particularly the fifth precept, which states, social justice for all the peoples of Indonesia. This principle is related to having a high national morality, as outlined Susilo Bambang Yudoyono the former President of Republic of Indonesia (Sumargono, 2010). In order to realise the notion of national morality, it is important for Indonesia to consider social justice for all of people.

In general, social justice recognises that each individual is an invaluable member of society. Following on from this idea, social justice involves ensuring that resources are distributed equitably amongst citizens, and that each individual has the responsibility to mutually respect others. Social justice denotes justice for the poor,

the exploited and the oppressed people in all societies, and encompasses the struggles of people everywhere who work for gender equality, intellectual protection and human rights (O'Kane, 2002).

In the world of education, the notion of social justice aims to provide equitable access to students, with respect to both the participation in and achievement of the curriculum. The provision of high quality education within a schooling system would be ideally combined with principles that provide substantive equality to all students, particularly those from marginalised groups. Keddie (2011) suggests that schools should provide inclusive environments where marginalised voices are heard (political justice), marginalised culture is recognised and valued (cultural justice) and marginalised students are supported in their academic achievement to successfully reap the material benefits of society (economic justice).

To implement teaching and learning for social justice, teachers need to move away from traditional teaching styles, as outlined previously, towards teaching approaches that provide students with what is required to achieve the highest standard possible. As a teaching framework, the Productive Pedagogies creates a space for teachers to discuss classroom activities with equitable and mutual responsibility, regardless of the students' backgrounds.

The present study examined whether the Productive Pedagogies framework, when used in the Indonesian setting, might serve to provide more equitable access for students, regardless of their backgrounds, in mathematics classes.

1.5 Research Aims

The overarching aim of the study reported in this thesis was to trial a teaching framework, in collaboration with a group of teachers (teaching and learning of mathematics at grade 7 in Indonesian schools), the Productive Pedagogies framework. Teaching mathematics using an educational framework is relatively new in the world and this research is probably the first of its kind in Indonesia. Given that the implementation of such a framework in the Indonesian context would require a shift in teachers' pedagogical practice (from a more traditional teaching style to one that would involve a more constructivist-oriented approach), it was likely to pose challenges to the teachers involved. Therefore, the first research aim sought to examine what challenges existed during the implementation process.

Research Aim 1

> To investigate the challenges associated with implementing the Productive Pedagogies framework in the teaching and learning of mathematics.

Given that the teachers' ability to critically reflect on their own work is a critical precursor to change, the present study sought to examine whether the Productive Pedagogies framework provided a useful tool that couldhelp to guide the teachers in this.

Research Aim 2

> To examine effectiveness of using the Productive Pedagogies framework as a tool for reflection.

The third research aim sought to examine the effectiveness of the introduction of the Productive Pedagogies framework in the Indonesian context in terms of three important outcomes. First, given that the effective implementation of the framework would require teachers to move from a teacher centred approach (in which lessons were delivered, largely, using a lecture style with little interaction with or between students) to a style in which student interactions were paramount to the learning process, the study sought to examine the effectiveness of using the Productive Pedagogies framework to improve classroom interactions and to connect mathematics so that it is relevant to students. Secondly, given that the underlying tenet of the Productive Pedagogies framework is to improve social justice, the study examined whether the social justice in mathematics classrooms was improved after the introduction of the Productive Pedagogies framework.

Research Aim 3

> To examine effectiveness of implementing the Productive Pedagogies framework in terms of improved a) classroom interactions, b) connectedness and c) social justice in mathematics classes.

Student engagement is an important factor in education. A student's willingness to participate in school activities and the effort he or she devotes to those activities contribute directly to a range of measurable outcome, including achievement. The

way that teachers' treat their students, and teaching strategies used are likely to impact on student engagement. Given the importance of student engagement in the learning process, the third research aim was to investigate the impact of the implementation of the Productive Pedagogies framework on students' engagement.

Research Aim 4

To investigate the impact of implementing the Productive Pedagogies framework, on students' engagement in mathematics classes.

1.6 Significance of the Research

The results of the study reported in this thesis are significant for a number of reasons. First, the study was, to the best of my knowledge, the first to have examined the implementation of the Productive Pedagogies framework, in Indonesia. Although the Productive Pedagogies framework had already been implemented in countries around the world with the aim of enhancing teaching and learning, this is the first to implement the framework in this context.

The present study is in keeping with the reform of the education system in Indonesia and, in particular, the Act of the Republic of Indonesia, Number 20, 2003, which focuses on the development of appropriate learning processes to optimise learning outcomes (Depdiknas. 2003a). As such, the results of the present study, serve to highlight the usefulness of the Productive Pedagogies framework in the Indonesian context.

The results of the study have the potential to provide significant weight to the encouragement of mathematics teachers in their quest to improve their teaching. It was anticipated that the teachers' involvement in the study would, potentially, improve their ability and skills and, as such, contribute to the reform of education in Indonesia. As a country undergoing education reform, the results of the present study offers a new perspective to teachers for the enhancement of mathematics teaching.

The results of the study have the potential to inform government officials, particularly policy makers in education, about how to improve the teaching and learning. The results highlight how changes in relationships among the members of classrooms and developing supportive learning environments might, in turn, improve student engagement in mathematics.

The results of the present study will provide significant weight to curriculum developers, with respect to using the comprehensive framework, to guide them in the development of comprehensive curricula that is not only related to teaching and learning in the classroom but also provides strategies to develop students' intellectual capacity.

1.7 Overview of the Thesis

The conceptualisation, design, implementation, and findings of this research are presented in five chapters.

This chapter, Chapter 1, has provided a backdrop for the study, by describing the Indonesian context and providing an overview of current reform efforts, based on recent acts that have been introduced to support these. Given that the study focused on mathematics classes, the chapter goes on to describe the current status of teaching and learning in mathematics education in Indonesia. The chapter introduces the Productive Pedagogies framework, used to guide teachers in their improvement efforts and its connection with social justice. Finally, the chapter introduces the aims of the study and provides information about the significance of the research described in this thesis.

Chapter 2 reviews literature that is relevant to the research described in this thesis. The literature review incorporates three main fields of relevance to the study. The first reviews literature related to theories of learning that focus on knowledge acquisition, constructivism and the development of mathematical knowledge. The second reviews literature related to mathematics teaching and what constitutes effective mathematics teaching. The third section outlines the Productive Pedagogies framework and social justice in education. The last section reviews literature related to student engagement in learning mathematics.

Chapter 3 details the research methodology and methods involved in the research. First, the chapter provides information about the research aims and the research methodology. The chapter goes into describe the research design, including the participants that were involved in the research, the research instruments used to gather information and the research procedures (including the workshop for teacher-participants, the implementation of the research, reflection and the reporting). The

chapter then goes on to describe the analysis of the data and the criteria used to ensure the trustworthiness of the research. Finally, the chapter details the ethical issues involved in the research and how these were overcome to ensure that the rights of participants were upheld.

Chapter 4 presents the findings of the study, based on data obtained during the implementation of the Productive Pedagogies framework. First, the chapter reports the findings of the analysis used to distil the challenges faced by the teachers as they implemented the framework. Second, the chapter reports the results of analysis related to the effectiveness of the Productive Pedagogies framework to improve teachers' reflection, the range of strategies used by students and student engagement.

Chapter 5 summarises the major findings of the study, outlining the implications of the application of the Productive Pedagogies framework for both teachers and students connected with the research aims. This chapter also describes the significance, explains the limitations of the research and provides recommendations to stakeholders and institutions and for future research.

Chapter 2
LITERATURE REVIEW

2.1 Introduction

The overarching aim of the study reported in this thesis was to investigate, on a small scale, whether the reform of mathematics education using Productive Pedagogies framework might be useful in Indonesia. Therefore, this chapter reviews literature related to the present study, including the theories of learning (focusing on knowledge acquisition, constructivism and development of mathematical knowledge) (Section 2.2), a review of what constitutes effective mathematics teaching (Section 2.3), the Productive Pedagogies framework (Section 2.4) and student engagement in learning mathematics (Section 2.5).

2.2 Theories of Learning

Given that, predominantly, the view of learning in Indonesia is one of transmission of knowledge, in which the teacher is the transmitter and students the receiver, the implementation of the Productive Pedagogies framework required teachers to reconsider how students learn and to change their teaching to reflect this. The research described in this thesis, in part, investigated the effectiveness of implementing the Productive Pedagogies framework which required teachers to reconsider deeply entrenched notions of teaching and learning. Therefore, this section discusses some of the theories of learning upon which the Productive Pedagogies framework was based.

This section describes literature related to theories of learning focusing on knowledge acquisition (Section 2.2.1) and constructivism (Section 2.2.2).

2.2.1 Knowledge Acquisition

A prevailing view of the human mind is that, essentially, it is empty of knowledge at birth and, throughout a person's lifetime, new knowledge is gradually acquired and utilised. This approach involves a set of initial premises, which form the basis for the development of a proposition for how knowledge is created, retained, distributed and used (van Beveren, 2002). Knowledge acquisition typically begins with the process of receiving or acquiring new knowledge. A review of literature indicates that there are two elements of knowledge acquisition: one is related to the theories of knowledge acquisition (conceptualising how knowledge is acquired and interpreted in the mind of learner); the other is a psychological perspective of knowledge acquisition (concerned with a person's ability to acquire knowledge and how it is internally represented) (Shakoor & Azeem, 2011).

Some approaches to knowledge acquisition have been built upon the idea that people have a predisposition toward knowledge or are born with certain values that already exist. This is usually done through visual or aural signals that a person receives through his or her senses. Van Beveren (2002) purports that information or knowledge is acquired through the sensors and is processed in the brain by using prior knowledge. During the processing of information, new knowledge can be acquired or created for future use.

Once information is received, knowledge acquisition continues through encoding and understanding that information. This encoding process allows a person to use information to build a cognitive model, called a schema (Zazkis & Leikin, 2009). That is, a schema for 'something' incorporates the received information to build an overall sense of what constitutes that 'something.' When a person sees another thing, for example, he or she processes the new information or knowledge and, when it does not fit the schema of 'something', he or she then creates a new model that accommodates that new knowledge. According to Zazkis and Leikin (2009), this knowledge acquisition continues with the ability to effectively recall and alter stored information. For instance, when someone sees 'something' again, he or she is able to recognise it as 'something' by recalling the schema for the 'something' and seeing that it fits into that model. This can create cognitive dissonance when someone encounters an object that exists within a certain schema, but which does not match certain aspects of that model.

In light of this proposition then, knowledge acquisition is the process of storing (absorbing and extracting), structuring and organising new knowledge in the memory, and relies on the process of acquiring, processing, understanding and recalling information through one of a number of methods. As a method of learning, the success of knowledge acquisition is related to how people experience new information, how that information is stored in the brain, and how that information can be recalled for later use from the memory. The utility of knowledge can be influenced by how the information is structured, and the process of storing and retrieving knowledge depends on the representation and organisation of the information.

The next section provides information about constructivism, a philosophy of teaching that was borne out of these principles of learning.

2.2.2 Constructivism

The dominant view of learning in Indonesia has, to date, been one involving a knowledge transfer model in which knowledge is transmitted from teachers to students (Azra, 2002: Zulfikar, 2009). However, if, as discussed above, knowledge acquisition is the process of acquiring, processing, understanding and recalling information, then this implies that learning is not simply a transfer process. This theoretical shift (to the notion that learners build their own knowledge) although not widely accepted or used, has started to take place in Indonesia (Armanto, 2002; Sembiring et al, 2008; Zulfikar, 2009). Given that the Productive Pedagogies framework, used in the present study, draws on the theory of constructivism in its design, this section provides a brief overview of constructivism.

As a theory of learning, constructivism asserts that people learn by actively constructing meaning rather than by receiving information (Hoban, 1997). According to von Glasersfeld (1995), learning requires the building of conceptual structures through learner reflection and abstraction; both of which are active processes involving the interaction between the learners' existing conceptual frameworks and the new knowledge and experience. Constructivism is not a teaching method but, rather, provides a framework for designing the teaching and learning processes in a real, complex, ever-changing and unpredictable classroom in which multiple factors –individual, social and cultural – are interacting (Fung, 2002).

Given that learners construct knowledge based on their personal experiences and past knowledge, it is likely that the nature of what is constructed may be different for different students, even though they are in the same classroom (Simon, 2008). In other words, learning is an individual activity and, therefore, no two students will leave a class with exactly the same understanding (Sutton et al., 1996). As such, it is important that teachers help students to examine their understanding of concepts. According to Gunstone (1995, p. 9), "the nature of an individual's personally constructed meaning is strongly influenced by his or her existing ideas and beliefs". That is, students' constructions of knowledge are influenced by their own views as well as by the nature of the learning and teaching process. It is important, therefore, that teachers are aware of their students' prior knowledge and experiences and consider these as a starting point when teaching, making use of them to develop students' new understanding within the lessons that they are delivering.

Among others, there are two well-known theorists who have laid the foundations for and have provided ideas that have been used in the development of the constructivist theory, Jean Piaget and Lev Vygotsky. This section provides a brief overview of the work of each.

Piaget introduced the notion that learners develop concepts through their interaction with the environment. His work, related to the cognitive development theory, led to a greater understanding of the psychological development of cognitive structures in children. Cognitive structures are patterns of physical or mental action that underlie specific acts of intelligence and correspond to stages of child development (McKeachie, 1994). According to Huitt and Hummel (2003) and McLeod (2009),

Piaget's cognitive structures consisted of four main periods of cognitive growth: sensorimotor, preoperational, concrete operations and formal operations. At the Sensorimotor stage (birth to two years) the mental structures are concerned mainly with the mastery of concrete operations (such as sucking or grasping) that are required for dealing with the immediate world. At the preoperational stage (aged two to seven years) children learn to think and to use symbols and internal images, however, their thinking is generally unsystematic and illogical. At the concrete operations stage (aged seven to 11 years) children develop the capacity to think systematically but only when they can refer to concrete objects and activities. At the formal operations stage (11 years and older) children develop the capacity to think systematically and at an abstract and hypothetical level.

Piaget's cognitive theory of learning provided a unique theoretical framework for learning. According to him, knowledge is not transmitted from teachers to learners but constructed in the mind of the learners. Piaget pointed out that, as the constructor of knowledge, learners acquired knowledge through inventing and reinventing their own knowledge through a process of adaptation. Adaptation is the change in cognitive structures or schemas which has two components, assimilation and accommodation. Assimilation involves the interpretation or incorporation of events in terms of existing cognitive structures, whereas accommodation refers to the changing or modification of existing schemes to make sense of the environment (Fox, 2006; Gruber, 2004; McLeod, 2009).

The implications of Piaget's theory for teaching of mathematics are that teachers need to provide a suitable environment for learning of mathematics based on the idea

that the acquisition of knowledge requires both action and interaction with the environment. According to Gadanidis (1994), because constructivist teachers' emphasise creating such a learning environment, students are more likely to create good schemas of mathematical understanding. Therefore, mathematics teachers need to be cognisant of and appreciate both mathematical and social learning by using teaching methods and approaches that allow learners to construct and re-construct mathematical knowledge in a culture of learning (Stephens & Sullivan, 1997). This suggests that, when teachers are planning mathematics lessons, they need to consider a range of possible schemas, and design learning activities that take into account of the diversity of students in terms of their abilities and experiences.

Vygotsky's (1978) approach differed somewhat to Piaget's. Whereas Piaget purported that learners developed concepts through their interaction with the environment, Vygotsky's theory underpinned the concept of social constructivism. His theory, known as socio-cultural learning, purports that the development of learning takes place through the medium of culture that was founded upon social collaboration. Development then, is a process that should be analysed, rather than a product to be obtained. For Vygotsky, the development process is one that begins at birth and continues until death and is too complex to be defined by stages (Hausfather, 1996). Further, Vygotsky purported that the life-long process of development was dependent upon social interaction and that social learning leads to cognitive development. This theory regards the relationships between social interaction, instruction and culture as fundamental to the acquisition of knowledge. Therefore, Vygotsky focused on the connections between people and the cultural context in which they act and interact in shared experiences (Crawford, 1996).

According to Vygotsky, then, cognitive development is directly related to social development and is a result of social interaction (Vygotsky, 1978). Therefore, learning as social construction places a greater emphasis on a dialogic process involving conversation (Drevier, Asoko, Leach, Morimer, & Scott, 1994).

With respect to learning mathematics, Cobb (1999) suggested that Vygotsky inspired a theoretical basis for the socially and culturally situated nature of mathematical activity. Vygotskians reorient the theoretical basis toward acquisition of what Vygotsky defined as scientific rather than spontaneous or everyday concepts. As such, Vygotsky viewed the learning of mathematics as the development of thinking and reasoning (Schmittau, 2004). One of the principles of Vygotsky's theory was the unity between mental functioning and activity, with the development of the mind resulting from goal-oriented and socially determined interaction among human beings, their tools and environments. According to Vygotsky, the only way to acquire knowledge was by doing so (Vygotsky, 1997) and that students learn by solving problems through their own thinking and reasoning. In this way , knowledge construction was determined by the interaction among students, teachers and the learning materials.

According to Vygotsky's theory, then, the teaching and learning of mathematics cannot be achieved through the interaction with concrete environments and a clear explanation of mathematical content alone, but it also requires "confrontation" among students, which can be facilitated by teachers.

An important principle associated with constructivism is the notion that all knowledge must be linked to and is built upon previous knowledge. Jonassen and Gabrowski (1993, p. 286) describe prior knowledge as "the knowledge, skills, or ability that students bring to the learning process". Past research has indicated that prior knowledge plays a major role in student learning and the implications that this has on mathematics teaching important (Tytler, 2002). The importance of the teachers' recognition and value for prior knowledge has been highlighted in past research (O'Tool, 2006; Davies & Walker, 2007). These theories suggest the need for teachers to recognise that students construct their own meaning and that prior learning can be used to facilitate student understanding.

In line with the constructivist theory, based on the works of Piaget and Vygotsky in particular, there are six components that underline a shift from treating students as learners and inquiries to treating them as members of a knowledge building community (Scardamalia & Bereiter, 2006), including:

- The advancement of knowledge as a community rather than as individuals.
- The advancement of knowledge being viewed as improvement rather than progress toward true or warranted belief.
- Knowledge in as opposed to knowledge about.
- Discourse as collaborative problem solving rather than as argumentation.
- Constructive use of authoritative information.
- The view of understanding as emergent.

The Productive Pedagogies, as a teaching framework, considers knowledge acquisition as the process by which new knowledge is received or acquired. The framework espouses that the success of knowledge acquisition is related to the process of acquiring, processing, understanding and recalling information, all of which are related to constructing knowledge. Therefore, consideration of knowledge acquisition as well as the construction of knowledge was viewed as important in developing effective teaching.

Based on the theories of knowledge acquisition as mentioned above, then, the next section distils the elements of what constitutes effective mathematics teaching.

2.3 Effective Mathematics Teaching

Given that the research sought to examine the impact of implementing the Productive Pedagogies framework it was considered important to examine literature related to what constitutes effective mathematics teaching and, in particular, the role of the teacher in optimising students' learning outcomes.

Mathematics is the most universal of all curriculum subjects, and mathematical understanding influences decision making in almost all of our daily life. Competence in mathematics has been identified as one of the key competences for personal fulfilment, active citizenship, social inclusion and employability in the knowledge society of the 21st century (Parveva et al., 2011). Even though competence in mathematics is an important factor that can increase a range of citizenship opportunities, unfortunately, many students still struggle with mathematics learning.

It is imperative, therefore, that we understand what effective mathematics teaching looks like.

The New Zealand Ministry of Education's Iterative Best Evidence Synthesis (Anthony and Walshaw, 2009, p. 6) suggests that effective mathematics teaching must be:

- Grounded in the general premise that all students have the right to access education and the specific premise that all have the right to access mathematical culture;
- Focused on optimising a range of desirable academic outcomes that include conceptual understanding, procedural fluency, strategic competence, and adaptive reasoning;
- Acknowledged that all students, irrespective of age, can develop positive mathematical identities and become powerful mathematical learners;
- Based on interpersonal respect and sensitivity and be responsive to the multiplicity of cultural heritages, thinking processes, and realities typically found in our classrooms; and
- Committed to enhancing a range of social outcomes within the mathematics classroom that will contribute to the holistic development of students for productive citizenship.

In recent years, there has been growing recognition that teachers are one of the most important factors in student achievement (Carey, 2004). As such, teachers should have the capability to create quality teaching by providing a learning atmosphere that supports each student in achieving his or her potential. According to Hayes et. al

(2006) effective teachers are central to positive outcomes for students and their practice towards improving student learning. Anthony and Walshaw (2009) purport that effective mathematics teachers are those which:

- Provide opportunities for student to work both independently and collaboratively to make sense of ideas;
- Plan learning experiences that enable students to build on their existing knowledge, proficiencies, interests and experiences;
- Understand that the tasks and examples they select influence how students come to view, develop, use, and make sense of mathematics;
- Support students in creating connections between different ways of solving problems, between mathematical representations and topics, and between mathematics and everyday experiences;
- Use a range of assessment practices to make students' thinking visible and to support students' learning;
- Are able to facilitate classroom dialogue that is focused on mathematical argumentation;
- Shape mathematical language by modelling appropriate terms and communicating their meaning in ways that students understand;
- Carefully select tools and representations to provide support for students' thinking; and
- Develop and use sound knowledge as a basis for initiating learning and responding to the mathematical needs of all their students.

Moreover, according to Anthony and Walshaw (2009), mathematics teachers play a strategic role in developing effective teaching and learning. As facilitators for their

students, they are the key factor in developing effective teaching whilst, simultaneously, creating opportunities for effective learning. Past research has indicated that there are a number of aspects which are important to effective teachers, such as, building intimate relationships with students, developing capability and self-confidence, facilitating students' intellectual demands and providing opportunities for students to learn productively (Slade, 2002). Students need teachers who are friendly, enthusiastic, caring and helpful; they want teachers who build relationships and inspire them to work hard and achieve success (Slade, 2002; Rowe, 2003). During the teaching process, a good relationship between a teacher and his or her students is considered to be important. According to Villenueva et al. (2007), both teachers and students 'will pay the price' if the teachers neglect to form emotionally supportive relationships with and among their students. Therefore, for improving students' chances for academic success, teachers should strive to create positive personal relationships with students.

Students are more likely to be emotionally and academically invested in the classes in which they have positive relationships with their teachers (Blum, 2005). Further, teachers who build positive relationships with their students may increase levels of students' interested in and enjoyment of the students' academic achievement (Murray, 2002). According to Pianta (1999), positive student-teacher relationships are characterised by open communication, as well as emotional and academic support. It is important for teachers to treat all students respectfully and to value them and their efforts proportionally (Bynton & Bynton, 2005).

It is generally agreed that there is a strong relationship between the quality of teaching and student attainment (Darling Hammond et al., 2005; Aaronson et al., 2007). As such, mathematics teachers should optimise their role in mathematics teaching to optimise students' mathematics learning outcomes by using their knowledge, skills, resources and incentives to provide students with the best of learning opportunities to achieve the best of learning outcomes. Anthony et al. (2009) suggest that an effective teacher should ensure that all students are given the opportunity to think and work by themselves, in which they are not required to process the varied, sometimes conflicting perspectives of others.

Research has indicated that, as teachers strive to improve the quality of their mathematics teaching, there are certain teaching strategies, methods or approaches are worthy of careful consideration (Grouws & Cebulla, 2000). Good teaching is reliant, not only on teachers' mathematical subject knowledge and skills, but also on their understanding of how to teach their subject and of how students learn – both of which are essential if teachers are to reflect on and respond to the needs of their students (Parveva et al., 2011). For example, the use of teaching strategies, methods or approaches will be meaningful only if the teacher knows when and how to use them properly.

Further, effective mathematics teaching, according to Parveva et al,(2011), depends, to a large extent, on the expertise of teachers; consequently their knowledge of the subject – of mathematical principles and processes – and their professional training are crucial. Therefore, it is important that mathematics teachers constantly monitor, adapt and improve the effectiveness of their mathematics teaching. As teaching is a

dynamic activity, the teacher, as learning facilitator, needs to frequently evaluate the effectiveness of their teaching. Further, the result of their evaluation should be used to improve the quality of their teaching

Effective mathematics teaching also requires that a mathematics teacher has the capability to consider students' diversity and to use suitable strategies that are suited to students' individual differences. Rehm and Allison (2006) state that all students are diverse, even those who are from the same cultural background. Respecting diversity requires that teachers look at all of the students with interest, openness and flexibility when providing lessons. It is important that teachers recognise that students may be considered at risk as the development of resiliency is a requirement of being successful. According to Sileo and Prater (1998), teachers who have been taught to appreciate diversity are more self-confident, have increased abilities, and move beyond judging students by superficial attributes such as skin colour, speech patterns and exceptionality. Hence, teachers need to be concerned with the importance of valuing and working with different students' backgrounds as an important element in developing effective mathematics teaching (Graetz, 1995).

To be effective, mathematics teaching should be intellectually relevant to students' needs. Therefore, applying appropriate intellectual demands on students and increasing students' involvement in their learning are crucial because these would influence their learning outcomes. Mills et al. (2009) suggests that high quality outcomes for students requires more than teachers simply changing their practices. In other words, to improve the quality of outcomes teachers need to improve the quality

of their instructions, and improving the quality of the instructions should include considering the students' needs, based on their backgrounds.

An important issue that has gained recognition in Indonesia in recent years is the notion of mathematical power (Sembiring, 2008). According to National Council of Teachers of Mathematics (NCTM, 1991), mathematical power is the ability to explore, conjecture, and reason logically; to solve non-routine problems; to communicate about and through mathematics; and to connect ideas within mathematics and between mathematics and other intellectual activity. In classes which involve mathematical power, students are engaged in mathematical tasks and discourse that require problem solving, reasoning and communication. Further, NCTM (1991) states that problem solving, reasoning and communication, as components of mathematical power, are processes that should pervade all mathematics instruction and should be modelled by teachers. It has been argued that mathematics teaching would be more effective if teachers were to consider the notion of mathematical power in their lessons.

To increase the effectiveness of mathematics teaching, teachers need to take into consideration the students' life experiences so that they can provide mathematics activities that are meaningful to students' daily activities. In other words, mathematics teaching should be intellectually relevant to students' world (Davis & Hersh, 1981). Given this, mathematics teachers should not only teach students 'what mathematics is' or the mathematics content in the curriculum, but should also show students, explicitly, how mathematics is applicable to their daily activities. Jeffes et al. (2013) state that in learning mathematics students should frequently undertake

activities that make connections between mathematics topics and can be applied to real-life situations. These involve showing the applicability of mathematics and increasing students' involvement in their learning. Further, Jeffes et al. (2013) suggested that students need to be given high quality tasks that require them to engage with the processes which are promoted, such as, problem solving; drawing out connections between mathematics topics; communicating in written form; justifying and providing evidence for their answers; and acquiring a deeper understanding of mathematics and how it can be applied. This finding implies that learning associated with high quality tasks, enables students to demonstrate their high level intellectual outcomes.

Newmann, Marks and Gamoran (1996) warned that it was possible for even highly active students to produce intellectually shallow work. To overcome this, they developed a framework, known as authentic pedagogy, to encourage teaching that introduces higher standards of intellectual quality. According to Newmann, Marks and Gamoran (1996) teaching and learning is authentic only when: knowledge is constructed and not transmitted; when the work builds on existing knowledge on the topic and is expressed in socially accepted terms and; and when the knowledge has values beyond the school. The criteria outlined in the authentic pedagogy framework can be used to judge the quality of assessment tasks, classroom lessons and student performance (Newmann et al., 1996). Since the development of this framework, numerous studies have built on the vision of authentic pedagogy (Newmann, Lopez & Bryk, 1998; Bryk, Nagoaka & Newman, 2000; Newmann Bryk and Nagoka, 2001). These studies have found: that when teachers assign tasks that are more challenging student performance improves (Newmann, Lopez & Bryk, 1998);

positive relationships between the intellectual quality of work given to students and their achievement (Bryk, Nagoaka & Newmann, 2000; Smith, Lee & Newmann, 2001); relationships between the intellectual quality of the work and improved skills (Newmann, Bryk & Nagoaka, 2001).

As a model, Authentic Pedagogy was viewed as highly theoretical and, therefore, its acceptance was mixed. According to Ladwig (1998), Authentic Pedagogy was difficult to use as a teaching frame work as it did not articulate effective teaching in a comprehensive way. As a result, work in Queensland used the basic tenets of Authentic Pedagogy to create the comprehensive framework, known as Productive Pedagogies. This theoretical framework was designed to enable teachers to critically reflect on their work (such as, classroom practices, designing curriculum and learning activities, individual students' needs) with a view to improving academic and social outcomes of students (Lingard, Hayes, Miles & Christie, 2003). Past research related to what constitutes effective including the mathematics teaching need for lessons inclusive, engage mathematical power, make appropriate intellectual demands of students in a supportive learning environment, which is equitable, accessible and values different cultural and socio-economic backgrounds all are important to the Productive Pedagogies framework.

Given that the research described in this thesis investigated whether reform of mathematics education using the Productive Pedagogies framework might be useful, the next section describes the framework and provides an overview of research related to the effectiveness of the framework.

2.4 Productive Pedagogies Framework

The Productive Pedagogies framework has its roots in the Queensland School Reform Longitudinal Study (QSRLS) that was carried out from 1998 to 2001 (Education Queensland, 2001). The QSRLS sought to examine the link between classroom practice and improved learning across four subject areas (English, mathematics, science and social sciences). Based on the data collected during the first year of the study, the research team developed the Productive Pedagogies model. Data gathered during the subsequent years of the study was then used to examine the fit of the theoretical model's underlying dimensions of classroom practices. Based on the results, the model was modified to incorporate and emphasis on the social outcomes of schooling (Lingard et al, 2001). Since this initial study, Productive Pedagogies has been taken up widely in Australia and internationally as both a research tool and metalanguage to support teachers as they critically reflect on their practice (Mills et al, 2009).

Research related to the Productive Pedagogies framework, which has expanded over the past decade, generally supports the Productive Pedagogies as a teaching framework (Lingard et al., 2002; Hayes et al., 2006). Lingard et al. (2001) purports that, when teachers use the Productive Pedagogies framework, students are provided with high quality education, especially those students from disadvantaged backgrounds. The framework provides a list of characteristics related to effective teaching that enables students to learn meaningfully. The Productive Pedagogies framework has been heralded as a means of creating an effective learning process that has a positive impact on students' academic and social outcomes (Gore, 2004).

The Productive Pedagogies framework, as described previously was based on the research model for school restructuring 'Authentic Pedagogies' and was modified for use in Queensland, Australia, as part of the Queensland School Reform Longitudinal Study (Hayes, et al., 2006). Since its use in Australia, as part of reform efforts in schools in Queensland, the Productive Pedagogies framework has been used in a range of countries including, China (Sun, 2013), Saudi Arabia (Alsharif, 2011), United Arab Emirates (Tanko, 2012), Oman (Alhosni, 2013) and Nigeria (Bature, 2014). My review of literature found that no studies, related to the use of the Productive Pedagogies framework have been carried out in Indonesia. Therefore, this study fills a gap in the literature by examining whether the Productive Pedagogies framework would be a useful tool in reforming mathematics teaching in Indonesia.

Since it was developed, the Productive Pedagogies framework has been used in a range of projects (see for example, Allen, 2003; Keddie, 2006; Keddie & Mills, 2007; Lingard, Martino, Mills, & Bahr, 2002; Louden et al., 2005; Marsh, 2007; Martino & Berrill, 2003; Munns, 2007; Pendergast et al., 2005). Whilst the framework emerged as a research tool for exploring and evaluating classroom practices it has since been presented as a useful metalanguage for teachers to critically reflect on and enhance their practice (Bature, 2014; Keddie, 2006; Lingard, Hayes, Mills & Cristie, 2003; Hayes, Mills, Christie & Lingard, 2006; Zyngier, 2005) and developed as an observation instrument (Mills, Goos, Keddie, Honan, Pendergast, Gilbert, Nichols, Renshaw, & Wright, 2009). The Productive Pedagogies framework has also be found useful in developing teachers' critical understanding and the use of higher order thinking (Zyngier, 2005). Further, the use of the Productive Pedagogies has been used to help teachers to recognise that engaging

students with differences in a supportive classroom was crucial for improved student outcomes (Allen, 2003; Zyngier, 2005).

As discussed in Chapter 1, the Productive Pedagogies framework involves four overarching dimensions, these being: intellectual quality (discussed in section 2.4.1); connectedness (discussed in section 2.4.2); supportive classroom environment (discussed in section 2.4.3); and recognition of difference (discussed in section 2.4.4). Each of the dimensions contributes towards the development of the skills, understanding, dispositions and knowledge necessary for students to become productive learners. This section discusses each of the four dimensions, in turn, and then discusses, in Section 2.4.5, social justice, an important underlying notion related to the implementation of the four dimensions.

2.4.1 Intellectual Quality

The intellectual quality dimension requires teachers to provide intellectual tasks and to engage students in higher order thinking and learning activities. Zevenbergen and Niesche (2008) argue that intellectual quality in mathematics tasks should enable and foster deep mathematical learning. Therefore, students should have opportunities to experience challenging activities. Past research has shown that, in schools that do not require students to complete work of a high intellectual quality, students do not attain high performance (Hayes, Mills, Christie, & Lingard, 2006). In contrast, the results of other studies suggest that there is a trend of improved effort and performance when students perform intellectually demanding tasks (Newmann, Bryk and Nagaoka, 2001). Research findings also indicate that, when teachers provide more

intellectually demanding tasks, students are more likely to produce high quality work (Koh & Luke, 2009). Lingard et al. (2001) examined the relationships between classroom practices and improved learning. This research found that the emphasis on the intellectual quality outcomes was related to student achievement. Further, Anthony and Walshaw (2008) highlighted teachers' assignment tasks and their associated activities influenced students' thinking and their sense of mathematics.

2.4.2 Connectedness

The connectedness dimension relates new knowledge with students' background knowledge and to their life outside of the classroom through identifying and solving real life problems (Education Queensland, 2002). By providing students with opportunities to engage in activities in which they can see the connection between what they are learning with their previous experiences and acquired knowledge they are better able to interpret the lessons and to build new concepts. There is widespread agreement that previous experiences and prior knowledge influence the learning process (see Section 2.2.2), and that learners construct new concepts based on previous experiences and prior knowledge. In turn, both of these indirectly affect the learning outcomes. Neglecting previous experiences and prior knowledge can result in the students learning something different to the teacher's intentions.

To assist students in their construction of new schemas, teachers need to consider students' prior knowledge and learning experiences when planning and implementing lessons. These experiences and prior knowledge exist not only at the level of concepts, but also at the levels of perception, focus of attention, procedural

skills and beliefs about knowledge. In addition, teachers need to consider providing students with opportunities to engage in activities that are connected with real world situations and with problems that are likely enhance students' understanding of their world both in and out of the classroom. Mills et al. (2009) believe that, if the work given to students is connected to their worlds, then this will stimulate intellectual activity that is likely to lead to higher intellectual outcomes. Similarly, Hayes et al. (2006) argue that pedagogies that connect the classroom with reality enable and motivate students to engage in the learning process. De Lange (1996) purports that, linking mathematics learning to real world situations, can improve students' understanding of mathematical concepts.

2.4.3 Supportive Learning Environment

The supportive learning environment dimension refers to aspects of teaching that support an effective teaching and learning process. According to Education Queensland (2001) the optimal classroom environment considers social support as well as the quality of classroom activities. Social support is present when teachers create good relationships between them and their students through conveying high expectations for all students.

Hayes et al. (2006) found that a supportive environment is an important aspect of a good classroom that can influence how effective students are in their learning. Past findings have found strong and consistent links between the notion of the learning environment and a range of students' outcomes both cognitive and affective (Fraser, 2001). These outcomes include student engagement (Anthony & Walshaw, 2008;

Veyalutham, Aldridge & Fraser, 2012; achievement (Boaler, 2008) and enjoyment of mathematics (Jeffer, 2013). A supportive classroom environment should not only provide a warm, friendly atmosphere but should also be one in which it is safe to take risks and to make mistakes without fear of ridicule or failure (Mills, 2010). Further, Anthony and Walshaw (2008) argue that mathematics teachers who produce effective classroom environments care about their students' engagement.

2.4.4 Recognition of Difference

The recognition of difference dimension is related to explaining how to systematically improve the achievement of students from disadvantaged sociocultural backgrounds. This dimension recognises that every student should feel that everything that they do in the classroom is valued. Students should also be aware that they are different to each other because their backgrounds are different, as are their views, opinions and works. Hayes et al. (2006) highlight that the recognition of difference dimension, in the Productive Pedagogies framework, deals with the substantial difference in the learning outcomes of students from different backgrounds. Sheets (2009) suggests that it is important that teachers value diversity in classrooms as well as understand and acknowledge the critical role of culture in teaching and learning. To this end, Hayes et al. (2006) suggest that knowledge should be presented in the classroom from different cultures, beliefs, languages, practices and ways of knowing. Similarly, Lee (2003) encourages teachers to provide explicit instruction about the dominant culture's rules and norms for students who do not come from the dominant culture. In mathematics teaching, the National Council of Teachers of Mathematics (NCTM) (2000) states that teachers need to understand

the strengths and the needs of students who come from diverse linguistic and cultural backgrounds, who have specific disabilities, or who possess a special talent and interest in mathematics. To accommodate differences among students effectively and sensitively, teachers need to understand and confront their own beliefs and biases.

2.4.5 Social Justice

An important aspect of the Productive Pedagogies framework is the notion of social justice as they relate to the educational context. The term 'social justice' was first used in 1840 by a Sicilian priest, Luigi Taparelli d'Azeglio, and was exposed by Antonio Rosmini–Serbati (1848) in *La Costitutione Civile Secondo la Giustizia Sociale* (Zajda et al., 2006). Whilst the term 'social justice' has become popularised in recent years (Paslay, 2011), it has escaped definition. It is not that the term is poorly understood but, rather, it is the problem that the term resists that eludes a concise and permanent definition (Riley, 2008). The concept of social justice varies slightly from person-to-person and from group-to-group, as a result of outside factors such as politics, religion, and social class (Paslay, 2011). Its meaning also may vary according to differing perspectives and social theories (Zajda et al., 2006). Not surprisingly, Gates et al. (2009) argue that social justice is not easily defined, in part, because it not only depends on one's own world view, but also because it depends somewhat on the situation being analysed. Thus, social justice is a relative concept, depending on whether we consider something as being socially unjust or relationally unjust.

Gates (2006) proposes that there are three forms of social justice:

(i) moderate forms, which focus on fairness and equity that tend to presume the continuance of the status quo, and do not explicitly recognise or relate to structural inequalities in society, which lie at the root of social injustice;

(ii) liberal forms, which recognise structural equalities and addresses those in some way that underlying this work is an acceptance that classrooms can be made more just within the existing structures; and,

(iii) radical forms, which recognise structural inequality and seeks to redress the ways in which inequality is built into existing practices and that changing the structures give greater access both objectively and subjectively.

Most conceptions of social justice refer to an egalitarian society that is based on the principles of equality and solidarity, that understands and values human rights, and that recognises the dignity of every human being (Zajda et al., 2006; p.1). No one is going to argue its main premise; the need for fairness and equality in society.

A socially just society is one in which gender, class, religion, social status and others, created by humans, do not exist and everyone has access to basic human rights. A socially just society is one in which there is an equitable distribution of wealth and property, and everyone's basic human and economic needs are met. A socially just society guarantees physical and psychological safety to its members. If these standards are not met, the society is termed as unjust and injustice prevails.

Social justice recognises that all individuals are invaluable members of society and the focus is on equity. Equity provides everyone with fairness, providing all people with equal rights which are applicable to everyone. O'Brien (2011) argues that equality and fairness are core aspects of social justice. These are drawn on extensively to define social justice and are reflected in their practice. Social justice is constructed as concerns related to the participation of social groups in social activity and their enjoyment of their fair share of social benefits. When living and participating in systems which are socially just, individuals or groups within society are provided with equitable outcomes. This happens as a direct result of the recognition of disadvantage and the existence of structural barriers in social, economic and cultural systems that perpetuate systemic discrimination. O'Kane (2002) points out that social justice denotes justice for poor, exploited and oppressed people and encompasses the struggles of people everywhere. In fact, we can argue that social justice targets marginalised groups of people in society and try to redress disadvantage.

This section describes social justice in as it applies to the educational context (Section 2.4.5.1) and social justice in and through mathematics education (Section 2.4.5.2).

2.4.5.1 Social Justice in the Educational Context

As discussed in Chapter 1, social justice principles facilitate individuals or groups as a whole and provide equitable approaches to achieving equitable outcomes by recognising disadvantage. In the education context, a school with a number of

classrooms can be viewed as microcosm of society, with students being the members of that society. All students, as members of the school community, should be given the opportunity to participate in the school environment to make education more dynamic (Howlett & College, 2008).

The QSRLS extended the ground-breaking work of Newmann and Associates (1996), one of the aims of which was to promote both overall increases in student learning outcomes and significant improvements in terms of social justice through a lessening of traditional equity-based gaps in student achievement. With its four dimensions of intellectual quality, connectedness, supportive learning environment and recognition of difference, the Productive Pedagogies framework explicitly attends to both intellectual and social justice outcomes (Gore et al, 2002). The provision of the Productive Pedagogies framework is more effective if it is combined with social justice principles, and the provision of substantive equality. Lingard and Mills (2007) referred to Productive Pedagogies framework as issues of social justice and inclusion. According to Atweh and Brady (2009) there was a range of research used in the Productive Pedagogies framework to develop a particular understanding of social justice, and how the framework impacts the notion of equality and fairness. For example, Gore, as cited in Van Helda (2002), argued that intellectual quality is about encouraging students to do learning work rather than busy work, but most of all it is about engaging students in big ideas and complex understanding. Gore argues that this dimension is directly related to social justice issues, in particular, providing challenging learning activities regardless of ability or social background. If the work given to students is connected to their worlds, a learning environment will be created that provides the opportunity to engage all students to do learning activities in which

they can see and connect what they are learning with their previous experience and acquired knowledge. A supportiveness of classroom is critical for the achievement of high level outcomes for students, especially for those who have traditionally been failed by the education system (Mills et al., 2009).

Finally, the recognition of difference dimension, creates classes in which difference is valued and, according to Mills et al. (2009) have the tendency for their learners to achieve academic success (especially those learners who time and again feel detached from school because they have perceived that their own difference is not respected within the classroom).

Social justice principles, therefore, are aligned with the dimensions of the Productive Pedagogies framework as these help teachers to consider social inequity and, in particular, disadvantaged students. While the Productive Pedagogies promotes the provision of a high quality education for all students, and especially students from disadvantaged backgrounds (Lingard et al., 2001). To be more effective, applying the principles of social justice, which is related to how the teachers treat their students, dictates that all students the right to equal treatment regardless of their background, the educational context need to be completed with applying social justice issues integrated with the content of the subject in order to internalise the principles of social justice simultaneously the concepts of the subject. Therefore the next sections discuss both social justice through mathematics (Section 2.4.5.2) and social justice in mathematics (Section 2.4.5.3).

2.4.5.2 Social Justice Through and in Mathematics Education

This section examines two important aspects that are related to mathematics education and social justice. The first, *social justice through mathematics education* is related to the internalising of the principles of social justice and mathematical concepts or the integration of social justice issues and principals into mathematics education. The second, *social justice in mathematics education* highlights the opportunity to treat all students in mathematics educational activities in ways that are fair and to provide equal rights to all students regardless of their background.

Social Justice through Mathematics Education. The notion of social justice *in* mathematics education is related to the integration of social justice issues and principles into mathematics education with a view to educating students to become agents of change. According to Alro (2010), the core aims of mathematics education should be concerned with understanding mathematics in society. Hoyles, et al. (1999) goes further to suggest that one of the central aims of the school curriculum should be concerned with understanding the place, purpose and power of mathematics in society. Further, it is recognised that the learning and practice of mathematics should not involve purely intellectual activities that are isolated from social, cultural and contextual factors (Cobb, 1994; Confrey, 1995; Gutstein, 2006).

Although making mathematics meaningful and useful, rather than merely presenting numbers, formulas and shapes, is widely recognised as important, it also is increasingly recognised that the larger aims of mathematics education are grounded, not only in academic aspects but, also, in social purposes (Alro, 2010). A movement,

known as humane mathematics education, promotes the use of mathematics education to help students to make sense of their world in ways that will help them to become agents of change.

Given that mathematics is a compulsory subject taught at all school levels, it has the potential to contribute to society. Popkewitz (2004) suggests that school mathematics is not the same as academic mathematics but is, rather, one of the many interfaces between mathematics and society. When students are able to use mathematics to better understand their needs in the world, and are able to develop creative and appropriate ways to meet those needs, the potential of mathematics as tool for social change is well on its way to being realised (Schmidt, 2011). The critical aspects of connecting mathematical ideas to students' worlds allow us to introduce and develop all students' mathematical concepts comprehensively.

If the learning and practice of mathematics involves social, cultural and contextual factors, it follows that students need to understand mathematics in a comprehensive manner and, at the same time, be encouraged to become agents of change. In this respect, the aims of mathematics should be to help students to understand mathematical content and to develop social agency within a particular socio-cultural context. As such, Gutstein (2006) contends that students must learn the subject matter with understanding because limited mathematical knowledge can prevent students from becoming agents of change.

In acknowledging the connection between mathematical ideas, students' worlds and social justice, it is important that students understand that mathematics is a part of

their life, and that it works in, and on, society. Therefore, functional mathematics should be introduced to support critical thinking and the appreciation of the social justice dimensions of mathematical applications. Moreover, Gutstein (2003) suggests that we use mathematics to understand relations of power, resource inequities and disparate opportunities between different social groups and to understand explicit discrimination based on race, class, gender, language and other differences. According to Hoyles et al. (1999), mathematics education in the third millennium should not only include teaching and learning mathematics, but should also include information about the nature of knowledge and the place of mathematics within society. As such, the quality of mathematics education is measured, not as formal abstraction and generalisation, but by its capacity to transform aspects of the life of the students both as current and future citizens (Atweh et al., 2009).

There is a dialectical relationship between developing mathematical power and teaching students to use mathematics to investigate, and potentially change structural in-equity. With this in mind, Gutstein (2006) suggests that students need to be prepared through their mathematics education to investigate and critique in-justice, and to challenge, in words and actions, oppressive structures and acts - that is, to 'read and write the world' with mathematics.

The study reported in this thesis, employed the Productive Pedagogies framework to help teachers to develop and use meaningful learning activities that tool into consideration notion of social justice. The implementation of the Productive Pedagogies framework in this study, included dealing with social justice issues experienced in students' daily life by involving mathematical problems that were

designed to help students to understand the world and, simultaneously, internalise social justice values and principles and are able to. In this way, the students were provided with opportunities to better understand and to be aware of social justice issues related to their lives. This corresponds to the focus of this thesis which involved the use of the Productive Pedagogies framework.

Social Justice in Mathematics Education. Social justice *in* mathematics education is related to how teachers apply the principles of social justice during the teaching and learning process. Social justice principles dictate that all students have equal rights to equal treatment in education. If students, regardless of their background, do not experience classrooms where they are intellectually challenged, then this is a matter of social injustice (Hayes et al., 2006). Social justice principles aim to overcome social injustices by providing equity in participation and achievement in the curriculum and are concerned with treating all students equally. Such equity requires not only equal access and opportunity, but also equal outcomes (Lesser, 2007).

Social justice in mathematics education involves teachers providing equitable access to students for their participation and achievement in the teaching and learning process regardless of their backgrounds. In many cases, teachers frequently conceptualise social justice principles as only one type of values in the teaching process while they actually have a more comprehensive concept of social justice in the classroom. Skovsmose (2005) states that when teachers only set problems that have just one right answer or problems that leave non-quantifiable aspects of the larger context unconsidered. In such cases the teacher's control over what counts as mathematical activity diminishes the potential for developing social justice.

Therefore, teachers need to create conducive learning environments that enable all students to equally participate in the whole of mathematics teaching and learning process, and at the same time, decrease instances of social in-justice in practice.

Teaching and learning for social justice is an educational philosophy that has been designed to promote socioeconomic equality or equity in the learning environment. Such equity requires not just equal access and opportunity, but also equal outcomes (Lesser, 2007). Further, teaching and learning for social justice encourages teachers to increase their consciousness and to develop a positive social and cultural identity regardless of their students' background. Treating students equally by applying social justice principles, it is expected to enable all students with their individual backgrounds to access and express their rights as learners based on equal opportunity. By concentrating on this, social justice is expected to improve interpersonal relationships among students and between students and their teachers as well as have a positive effect on school culture in mathematics education.

The four dimensions of the Productive Pedagogies framework are aligned with social justice principles. An important aspect of the Productive Pedagogies framework is the notion of social justice as it relates to the educational context. By applying the various dimensions, the Productive Pedagogies framework explicitly attends to social justice principles in the classrooms.

The present study built on and extended these past studies by incorporating social justice principals into the Productive Pedagogies framework. The Productive Pedagogies framework is designed to achieve this concept of social justice through

good teaching that will narrow the gap between different social groups (as recommended by Hayes et al., 2006).

2.5 Student Engagement in Mathematics Classes

One of the aims of the research reported in this thesis was to investigate whether students' engagement in learning mathematics was improved when teachers implemented the Productive Pedagogies framework. Therefore, this section reviews literature relevant to student engagement. According to the Merriam-Webster dictionary, engagement is an emotional involvement or commitment. Mann (2001) contrasts 'engagement' with 'alienation', arguing that an engagement–alienation dyad is a useful framework to use to understand students' relationship to their learning.

Numerous studies have identified student engagement as a desirable trait in learning; however, there is a little consensus on how to define what student engagement is. Definitions of student engagement, in general, include both a psychological and behavioural aspect. Psychological aspects, also referred to as emotional aspects, involve affective reactions such as interest, enthusiasm, excitement and enjoyment. While the behavioural aspect is more closely related to attitudinal reactions such as attending classes, following teachers' directions, participating in learning activities and submitting required work (Chapman, 2003).

According to Willms (2003), student engagement refers to students' attitudes towards school, while student dis-engagement identifies withdrawing from school in any

significant way. Stovall (2003), on the other hand, defines student engagement as a combination of time on task and students' willingness to participate in activities. Fletcher (2005) provides a similar understanding, stating that student engagement includes participating in the activities offered as part of the school program. Krause and Coates (2008) consider student engagement to be related, not only to the participation but, also, to the quality of the effort that students devote to educationally purposeful activities that contribute directly to desired outcomes. Similarly, Kuh et al. (2007) define student engagement as participation in educationally effective practices, both inside and outside of the classroom, which leads to a range of measurable outcomes.

It is widely agreed that students who are engaged show sustained behavioural involvement in learning activities that are accompanied by a positive emotional tone (Skinner & Belmont, 1993). Engaged students select tasks at the border of their competencies, initiate action when given the opportunity, and exert intense effort and concentration in the implementation of learning tasks; they show generally positive emotions during ongoing action, including enthusiasm, optimism, curiosity, and interest (Skinner & Belmont, 1993). Engagement, therefore, is more than involvement or participation as it requires feelings and sense making as well as activity (Harper & Quaye, 2009).

Although many studies investigate only one dimension of student engagement, it is widely accepted that student engagement is a multidimensional construct. Fredericks, Blumenfeld and Paris (2004) classified 44 engagement studies into three dimensions of student engagement: behavioural engagement; emotional engagement and

cognitive engagement. They argue that students who are behaviourally engaged would typically comply with behavioural norms, such as attendance and involvement, and would demonstrate the absence of disruptive or negative behaviour. Students who engage emotionally would experience affective reactions such as interest, enjoyment, or a sense of belonging. Students who are cognitively engaged would be invested in their learning, would seek to go beyond the requirements, and would relish challenge.

Anderson, Christenson, Sinclair and Lehr (2004), on the other hand, divide engagement into four types: behavioural; academic; cognitive; and psychological. Their categories are similar to those described by Fredricks et al. (2004) but, according to Harris (2008), they use academic engagement to specify the time spent doing learning activities as opposed to general behavioural engagement where students may be participating in non-academic pursuits. In their model, psychological engagement encompasses similar aspects to Fredricks et al.'s (2004) emotional engagement. Additionally, Schlecty (1994) purports that students who are engaged exhibit three characteristics, these being, that they are attracted to their work, they persist in their work despite challenges and obstacles, and they take visible delight in accomplishing their work.

Exploring the question of student engagement has raised discussions about the purpose of education. The purpose for education has, overtime, changed because the world has changed. As the world has changed so too have students, however, it would appear that, in some respects, education has not followed suit. Research suggests that a gap could exist between what students want and what students need;

inviting room to rethink the purpose of education. As a consequence, the old commitment to equal educational opportunity could be replaced by a promise of optimal benefits for all students by providing clearly learning criteria, appropriate teaching approaches, qualified learning activities and supportive learning environment.

It is widely agreed that engaging students at school fosters the development of creative, informed and resilient citizens. Engagement at school also leads to many benefits for individuals and society, including higher levels of employment and earnings, better health, longevity, tolerance and social cohesion (Gonski, Boston, Greiner, Lawrence, Scales & Tannock, 2011).

Theobald (2006) noted that students' lack of interest in learning is an issue that needs to be addressed. Further, Theobald (2006) stressed that stimulating students' engagement to learn remains one of the greatest challenges for teachers. While researchers generally agree that improving student engagement in school work is a high priority, and a necessary precondition for boosting student achievement, there is less certainty about how to accomplish this (Theobald, 2006).

Research indicated that students who are engaged show sustained behavioural involvement in learning activities (Pintrich, 2003). They select tasks at the edge of their competencies (Bandura, 1986), initiate action when given the opportunity (Schunk & Pajares, 2005) and exert sustained intense effort and concentration in the implementation of learning tasks (Boekaerts & Cascallar, 2006; Boekaerts & Corno, 2005). Engaged students in general are likely to show positive emotions during

ongoing action, including enthusiasm, curiosity, and interest. At the opposite end of the continuum to engagement is disaffection. Students who are disaffected are passive, do not try hard and give up easily in the face of challenges. Disaffected students can be bored, depressed, anxious, or even angry about their presence in the classroom. They tend to be withdrawn from learning opportunities or even rebellious toward teachers and classmates (Neo & Neo, 2009).

It is unclear who is responsible for student engagement. Hu and Kuh (2001) argue that student engagement is related to the quality of the students' efforts that are devoted to educational activities and contribute directly to desired outcomes. This view places the responsibility of engagement on student individually. That is, individual learners are ultimately the agents of student engagement. Coates (2005, p. 26), on the other hand, states:

> The concept of student engagement is based on the constructivist assumption that learning is influenced by how an individual participates in educationally purposeful activities. Learning is seen as a joint proposition which also depends on institutions and staff providing students with the conditions, opportunities and expectations to become involved.

In short, Coates argues that student engagement is the joint responsibility of students, teachers and their schools. Kuh (2004) also purports that student engagement is dependent upon factors related not only to the student but also the teacher and wider school environment.

Student engagement, according to Kuh (2004) requires that the whole school, rather than teachers as individuals, to actively seek to create the conditions that foster students' engagement. They need to consider the development of a whole-school definition of student engagement that includes a clear articulation of learning criteria with clear, immediate, and constructive feedback; showing students the skills they need to be successful and that these are within their grasp. Further, schools need to foster the belief that engagement in learning is a valuable aspect of a student's personality.

The literature identifies a wide range of perspectives related to the purpose of student engagement. According to Trowler (2010) student engagement is important for a number of reasons, including: improved learning; improved equality and social justice; improved curricular relevance; and institutional benefit. The majority of literature related to student engagement is concerned directly or indirectly with improving student learning. According to Coates (2005) the concept of student engagement is based on the constructivist assumption that learning is influenced by how an individual participates in educationally purposeful activities. In essence, therefore, student engagement is concerned with the extent to which students are engaging in a range of educational activities and how this engagement is likely to lead to high quality learning. Researchers have acknowledged that an essential key to successful mathematics learning is a positive motivational belief that mobilises otherwise inert knowledge (Hanrahan, 2002). When students have higher motivation, their satisfaction with their learning is greater which, in turn, can lead to better learning outcomes (Fraser, 2012).

Research indicates that students' successful learning engagement in mathematics is primarily determined by their level of motivation and self-regulation in mathematics learning (Boekaerts & Cascallar, 2006; Hanrahan, 2002; Kaplan et al., 2009; Velayutham, Aldridge & Fraser, 2011; Zimmerman, 2000). The interactions between behavioural, environmental and personal determinants that are proposed in the social cognitive theory suggest that relevant aspects of the learning environment will affect both students' motivational beliefs and their self-regulation.

There are two types of motivation; intrinsic and extrinsic motivation (Al Hmouz, Wilma & Rose, 2010). While intrinsic motivation is perceived as the doing of an activity for its inherent satisfaction, for example, the enjoyment of school learning is characterised by an orientation toward mastery, curiosity, and the learning of challenging and novel tasks (Gottfried, Gottfried,Cook& Morris, 2005; McInerney, 2002; Phillips & Lindsay, 2006), extrinsic motivation is related to doing something that leads to a separate outcome. Extrinsic motivation is generally associated with winning; therefore students tend to concentrate more on the prize than on the satisfaction derived from learning (Phillips & Lindsay, 2006; Ryan & Deci, 2000).

Research has revealed that students' engagement in mathematics learning plays a pivotal role in their conceptual change processes, critical thinking, learning strategies, and achievement in mathematics (Kuyper, van der Werf, & Lubbers, 2000; Lee & Brophy, 1996; Pintrich, Marx & Boyle, 1993; Wolters, 1999). Psychologists have spent considerable effort trying to construct theories of motivation, particularly in the academic context. Currently, there are a number of prominent theories which are prominent in contemporary educational psychology

including the self-efficacy theory, attribution theory, self-worth theory, achievement goal theory and task value theory.

It is becoming increasingly recognised that the critical factor in the learning process may be related to how students react to their environment (Dumont, Istance, & Benavides, 2010). Environments which are perceived as being nurturing, supportive and helpful will develop, in students, a sense of confidence and self-determination which will be translated into the learning-oriented behaviours of the intrinsically motivated student (Seifert, 2004; Seifert & O'Keefe, 2001).

Student engagement has the potential to enhance equality and social justice in our education system (Harper & Quaye, 2009). Kuh (2009) believes that engagement has effects on achievement and persistence for students who most need a boost to performance. Moreover, Kuh purports that engaging in educationally purposeful activities helps to level the playing field, especially for students from low-income family backgrounds and others who have been historically underserved. In this respect, engaging students from a range of backgrounds, including economically disadvantaged students, students from ethnic minorities, students with disabilities and students with family responsibilities, will help to ensure that they have an equal chance of success. Harper and Quaye (2009, p.3) state "We are persuaded by a large volume of empirical evidence that confirms that strategizing ways to increase the engagement of various student populations, especially those for whom engagement is known to be problematic, is a worthwhile endeavour".

Given that student engagement is likely to influence the quality of students' efforts, thereby contributing directly to the desired outcomes, it is important that the implementation of the Productive Pedagogies framework considers students' engagement in learning activities.

2.6 Chapter Summary

This chapter has reviewed the literature pertinent to the research. The chapter first reviewed literature related to theories of learning and development of mathematical knowledge. Learning mathematics can be viewed as the interaction between what the learners knows, the new information that they encounter and the learning activities that they engage in to develop their mathematical knowledge. As such, the mathematics teachers is required to provide students with as many opportunities as to construct their own understanding through experience, interactions with content and others, and reflection.

The chapter went on to review literature related to what constitutes effective mathematics teaching. In reviewing the literature, it is clear that effective mathematics teaching is not only related to teachers' mathematical subject knowledge and skills, but also on their understanding of how to teach mathematics and of how the students learn mathematics. Additionally, effective mathematics teaching considers students' diversity, use suitable strategies that are suited to the differences and are intellectually relevant to students' needs.

The chapter then described the theory behind the Productive Pedagogies framework. The dimensions (and the elements) of the Productive Pedagogies framework and how these are aligned with the principles of social justice. The chapter describes how the Productive Pedagogies framework has been used to help teachers to promote the provision of a high quality education for all students and to consider social inequity and disadvantaged students. Further, the chapter describes and distinguishes between social justice through and in mathematics education offer. The chapter examines the importance of teachers ensuring their students have equal rights to get equal treatment regardless of their background and the notion of integrating social justice issues with the lesson content.

Finally, the chapter reviewed student engagement in learning mathematics. The chapter defined student engagement and how it can be considered in three broad dimensions, these being, behavioural engagement (which is complied with students' behavioural norms, such as attendance and involvement, and would demonstrate the absence of disruptive or negative behaviour), emotional engagement (in which students experience affective reactions such as interest, enjoyment, or a sense of belonging), and cognitive engagement (which is invested in students' learning that seek to go beyond the requirements and to be challenged). Finally, the chapter examined the importance of engagement in the education context and what this means for mathematics teachings and learning.

Chapter 3
RESEARCH METHODS

3.1 Introduction

Whereas the previous chapter reviewed literature pertinent to the present study, this chapter describes the research methods used. This chapter starts with a reiteration of the research aims, introduced in Chapter 1 (Section 3.2). The chapter goes on to detail the research methodology (Section 3.3) and research design (Section 3.4). Finally, the chapter describes the criteria used to ensure the trustworthiness of the research (Section 3.5) and how the ethical issues related to this research were addressed (Section 3.6).

3.2 Research Aims

As stated earlier, the overarching aim of this research was to trial, in collaboration with a group of teachers, the Productive Pedagogies framework in the teaching and learning of mathematics at grade 7 in Indonesian schools. The specific research aims, introduced in Chapter 1, are reiterated here.

Research Aim 1

> To investigate the challenges associated with implementing the Productive Pedagogies framework in the teaching and learning of mathematics.

Research Aim 2

To examine effectiveness of using the Productive Pedagogies framework as a tool for reflection.

Research Aim 3

To examine effectiveness of implementing the Productive Pedagogies framework in terms of improved a) classroom interactions, b) connectedness and c) social justice in mathematics classes.

Research Aim 4

To investigate the impact of implementing the Productive Pedagogies framework, on students' engagement in mathematics classes.

3.3 Research Methodology

The study reported in this thesis used action research as the research methodology which, according to Kemmis and McTaggart (1988), is a form of collective self-reflective enquiry undertaken by participants in social situations, to improve their own social or educational practices. This enquiry sought also to further the participants' understanding of the practices and the situations in which the activities were carried out.

Ger (1997) argues that action research begins with practical problems that are related to a group of people, the solutions for which lie in the locale. In accordance with this, Creswell (2008) suggests that the characteristics of action research include: a

practical focus; the educator-researcher's own practices; collaboration; a dynamic process; a plan of action; and, a sharing of the research. Action research is, according to Miller (2003), a work in progress in shaping practice, in defining goals, in articulating theoretical frameworks, and in discovering ways in which a shared understanding can be realised.

As a research methodology, action research is concerned with real situations and is more likely to involve flexible rather than experimental studies; which tend to be more contrived. Moreover, action research is demanding because researchers are expected both to develop knowledge and to work toward social change. Ger (1997) adds that action researchers should be committed to extending social theories beyond the local context in which the research takes place, to inform wider improvements in society.

Action research was considered to be suitable for the present study because of its overarching characteristics. At each stage of the action research, the teachers were supported by the researcher as they developed, implemented and evaluated the program in three cycles to address the research aims. As described by Kemmis and McTaggart (1988), the process involved a repeating spiral of three stages: 1) plan; 2) act and observe; and 3) reflect. As such, action research, in this study, involved an investigation, where, as a result of rigorous self-appraisal of current practice, the teachers focused on a problem, a topic, or an issue which needed to be explained. On the basis of this information, the teacher then planned, implemented and evaluated an action, drawing conclusions on the basis of the findings (a sequence recommended by Macintyre, 2000).

Therefore, action research was used to explore aspects relevant to the four research aims of the study.

3.4 Research Participants

The research was conducted in Lembang County, West Bandung District, West Java Province, Indonesia. I chose this location for practical reasons because: 1) it was close to where I lived and worked (thereby providing me with adequate access to schools); 2) the schools in this area included both urban and rural areas and represented the range of schools in Indonesia.

From this district, I purposively selected two schools, the names of which have been changed to protect the identity of the teachers. One school was located in an urban area (State Junior High) and the other was located in a rural area (Mekarsari Junior High). (Note that the names of the schools have been changed to protect the identity of the teachers.) The urban school, State Junior High was a public school with access to a range of school facilities and was located in the centre of Lembang District. The rural school, Mekarsari Junior High, on the other hand, was a private school with limited school facilities, funded by a social foundation and located in a hilly rural area. State Junior High was populated with students from a higher socioeconomic background with most parents being civil servants, businessmen and women and private sector employees. Mekasari Junior High was populated with students from a lower socioeconomic background, with some parents being labourers and many who did not have a steady job. The selection of schools was intended to maximize variation between schools.

The study involved four Year 7 mathematics teachers (two of whom were selected from each of the urban and rural schools) and their classes. Two of the teachers, Yanti and Yayu, taught at State Junior High (the urban school) and the other two, Nurjanah and Wawan, taught at Mekarsari Junior High (the rural school) (Pseudonyms have been used to protect the identity of the teachers.)

Yanti, a teacher at State Junior High, had 12 years' teaching experience in a number of junior high schools. She had completed her bachelor degree in 1998 (14 years prior to this study), and also had 2 years of primary school teaching experience. She had, over the years, attended many professional development programs, such as mathematics curriculum workshops and classroom action research training.

Yayu, a teacher at State Junior High, had 9 years' teaching experience. She completed her bachelor degree in 2003 (9 years prior to this study) and had also attended numerous professional development programs, including mathematics curriculum workshops and teaching and learning training.

Nurjanah, a teacher at Mekarsari Junior High, had 23 years' teaching experience in a number of junior high schools, and she had almost completed her master's degree at the time of this study. She had, prior to this study, attended a number of educational courses including training in how to plan lesson and a short course on action research as well as mathematics curriculum workshops. In addition to being a mathematics teacher, Nurjanah was also the principal of Mekarsari Junior High.

Wawan, a teacher at Mekarsari Junior High, had 8 years' teaching experience. He had completed his bachelor degree in 2003 (9 years prior to this study). He had been a primary school teacher for three years before becoming a high school teacher. He had, prior to this study, attended a number of professional development programs, including mathematics curriculum workshops and classroom action research training.

In all cases, these teachers taught Year 7 classes. This year level was selected for inclusion in the study for a number of reasons. First, given the nature of the Productive Pedagogies framework, which promotes active engagement, year 7 students were considered ideal as, according to Hart (2011), middle school students have a desire for active involvement in learning and were curious. Importantly, however, year 7 is the first year of junior high school in Indonesia and, as such, the pressure of examinations were somewhat reduced when compared to subsequent years. It was anticipated, therefore, that the implementation of the teaching approaches, associated with the Productive Pedagogies framework, was more likely to be carried out successfully at this year level.

In the rural school (Mekarsari Junior High), there were, in total, only two mathematics teachers who taught Year 7. When asked to be involved in this study, both of the teachers accepted. In the case of the urban school (State Junior High), there were four Year 7 mathematics teachers, two of whom were invited to be involved in the study. Both of these teachers accepted. As described earlier, the experience of the four teachers ranged from 10 to 25 years and they were aged between 28 and 44 years of age. The teachers were all involved in every aspect of the data collection (described below).

Each of the four teachers selected a Year 7 class that would be involved in the study. Given that the class groupings, at both the urban and rural school, were not based on ability, it was assumed that a range of abilities would be present in classes in both of the schools. The class sizes, at both the urban and rural schools, ranged from 23 to 30 students. Students from each of these classes were selected and asked to be involved in focus-group and in-depth interviews. For the focus-group interviews, 3 groups of four to six students were randomly selected from each class at different stages of the research. The details of the focus-group interviews are provided in Section 3.4.2.2. The selection of students for the in-depth interviews was purposeful and was made in consultation with the teachers to ensure a representative research subjects that included a range of abilities and socio-economic backgrounds. Table 3.1 provides a breakdown of the number of teachers and class sizes for each of the schools.

Table 3.1 Overview of Participants

Name of School	Number of Teachers	Number of Students	
		Class A	Class B
State Junior High	2	28	30
Mekarsari Junior High	2	23	24
Total	4	51	54

3.5 Research Procedure

Prior to the commencement of the research, I obtained permission to use copyright materials associated with the Productive Pedagogies framework. The letter of permission can be found in Appendix 1.

An important component of the present study was to make the Productive Pedagogies framework accessible to teachers in Indonesia. Therefore, before the commencement of the study, the framework was translated into Bahasa Indonesia, the national language. A copy of the translation can be found in Appendix 2.

Prior to the implementation of the Productive Pedagogies framework, I conducted a five-day workshop with the teacher-participants. The workshop involved an orientation program to help the teachers to understand: (i) the aim of the research; (ii) the role of teacher-participants in the research; (iii) the Productive Pedagogies framework; and, (iv) how to design lesson plans and learning activities using the Productive Pedagogies framework.

On each of the five days, the workshop ran from 8 am to 4 pm and was attended by all of the four teacher-participants who implemented the framework. After attending the workshop, the teachers worked each day to develop lesson plans and learning activities using the Productive Pedagogies framework for the mathematics topics that they would teach. Once the lesson plans and activities were developed the teachers were expected to implement them using an action research process.

The study involved three action research cycles each consisting of approximately four weeks. Data was gathered during each of the action research cycles. The action research process involved a repeating spiral of three stages: 1) plan; 2) act and observe; and 3) reflect (as recommended by Kemmis & McTaggart, 1988). These stages are portrayed graphically in Figure 3.1 and described in more details below.

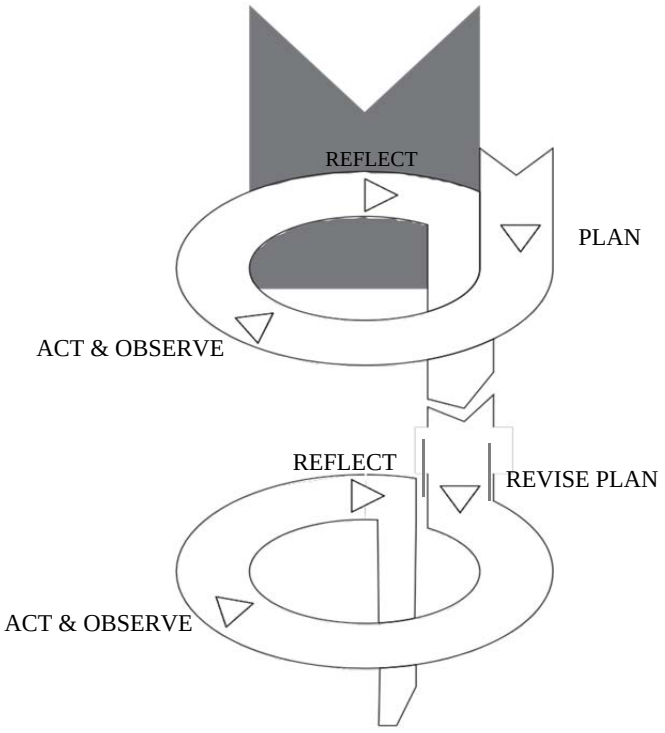


Figure 3.1 Kemmis and McTaggart's Action Research Spiral

At the *planning* stage of the action research process, the teacher-participants, supported by me, developed mathematics lesson plans and learning activities, including students' worksheets, projects and the form of evaluation. This stage extended what they had learned and produced during the five-day workshop. All of the mathematics lesson plans and learning activities were developed with reference to the same curriculum, *Kurikukulum Tingkat Satuan Pendidikan 2006* (School-

Based Curriculum). Therefore, the topics taught in both of schools were the same; integers and fractions focusing on operations, graphs and solving problems.

The *action* stage was conducted by the teachers, individually. During this stage, the teachers were observed (as described in Section 3.4.2.1) as a means of monitoring the teaching and learning process. The classroom observations, carried out by myself and the other teacher-participant who taught at the school, were guided by an observation schedule. As mentioned previously, the teaching and learning was recorded using a video camera and field notes. The main purpose of the classroom observations was to identify the extent to which learning was taking place and the effectiveness of the teaching approaches involved in enabling learning.

The *reflection* stage was held immediately after the observations. Both of the teacher-participants who taught at the same school were involved in this session, which included reflecting and evaluating the teaching and learning that took place during the observations. The data collected during the classroom observations were analysed and the findings were interpreted in light of how successful the teachers' action had been. This analysis was followed by several possible solutions, from which a single plan of action emerged and was considered for the improvement of the next cycle. The teacher then used this information to begin another cycle of action research.

At the end of each action research cycle, the four teacher-participants and I met to report our individual findings. During this meeting, the teacher-participants reported their experiences, impressions and opinions as well as any problems that they had

experienced during the implementation of the program. During the meeting, I facilitated dialogue between the teacher-participants and conducted reflective activities about matters which arose, related to the implementation of action cycles.

Finally, after all of the action research cycles had been completed, the teacher-participants and I reflected on the process as a means of evaluating the implementation of the teaching and learning activities, with particular reference to the research aims.

3.6 Research Instruments

To address the different aims of the study, the collection of data involved classroom observations (described in Section 3.6.1) and interviews (described in Section 3.6.2). Table 3.2 provides an overview of the relationships between the research aims, data source and the data collection methods, each of which are expanded upon in the subsequent sections.

3.6.1 Classroom Observations

To investigate all three research aims, including examining the challenges associated with implementing the Productive Pedagogies framework (Research Aim 1), the effectiveness of using the Productive Pedagogies framework the teaching and learning process (Research Aim 2), and student engagement (Research Aim 3) classroom observations were used. According to Creswell (2008), observation is the process of gathering first-hand information by observing people and places at a

research site. As such, classroom observations offered me a direct way of collecting evidence of what was actually happening, as recommended by Denscombe (2003).

Table 3.2 Relationship betweenResearch Aims, Data Source and Data Collection Methods

Research Aim	**Data Source**	**Data Collection Methods**
To investigate the challenges associated with implementing the Productive Pedagogies framework in the teaching and learning of mathematics	Students and teachers	- Classroom observations - Focus-group interviews (teachers)
To examine effectiveness of using the Productive Pedagogies framework as a tool for reflection.	Teachers	- Classroom observations - Focus-group interviews (teachers)
To examine effectiveness of implementing the Productive Pedagogies framework in terms of improved a) classroom interactions, b) connectedness and c) social justice in mathematics classes.	Students and teachers	- Classroom observations - Focus-group interviews (students and teachers) - In-depth interviews (students and teachers)
To investigate the impact of implementing the Productive Pedagogies framework on students' engagement in learning mathematics.	Students	- Classroom observations - Focus-group interviews (students and teachers) - In-depth interviews (students)

All of the classroom observations were conducted by me and a participating teacher. The participating teacher was always the other teacher who was teaching at the school. In this way, all of the teacher-participants were able to observe the other participating teacher at their school and to be observed by both me and the other participating teacher. Immediately after all of the lessons, both of the participating

teachers (one who taught and the other who observed) and I met to discuss the lesson and what had been observed.

All four teachers and their classes were observed for a minimum of two but sometimes three, lessons a week, each of which were 80 to 90 minutes in duration (depending on the teachers' weekly schedule).These observations were carried out over thirteen weeks. The classroom observations were used to provide information about, firstly, how the teachers used the knowledge and skills related to the Productive Pedagogies framework in their mathematics teaching practices and, secondly, student engagement. The classroom observations were also used to gauge and monitor the quality of the teaching and learning process, allowing me to examine how the teachers performed as they introduced mathematics using the Productive Pedagogies framework.

The focus of the classroom observations was on identifying the extent to which learning was taking place and the effectiveness of the teachers' strategies to enable learning. Additionally, the classroom observations were used to encourage self-evaluation by the teachers and to provide support and guidance for teachers and to access professional development where required. Further, the discussions held after the classroom observations provided feedback that the teachers could use to help them develop subsequent mathematics lessons.

During the classroom observations, the observers (the teacher-participant who acted as the observer and I) were non-participants in the process and made every attempt to minimise disruption to the activities of the teacher and the students. In this respect,

the observers made no comments and did not assist students in their activities during the observations.

In the implementation of the classroom observations, the observers were guided by the Productive Pedagogies Classroom Observation Manual published by the Queensland School Reform Longitudinal Study (QSRLS) commissioned by Education Queensland (Education Queensland, 2001). (A copy of the letter of permission from the Department of Education Training and Employment Queensland, pertaining to the use of copyright materials related to the Productive Pedagogies framework, can be found in Appendix 1) A copy of the Observation guide, in English, can be found in Appendix 3. To enable the teacher-participants to understand the framework and how their practices would be observed, the classroom observation manual was translated into the Indonesian language. A copy of the Observation Guide, in Indonesian, can be found in Appendix 4. To ensure the accuracy of the intentions of the observation manual, after being translated by me into the Indonesian language, it was sent to a lecturer in English in the English Education Department of the Indonesia University of Education. Moreover, the lecturer and I discussed the most accurate ways to convey English expressions within the Productive Pedagogies Classroom Observation Manual.

The manual was used (as recommended by the Department of Education, 2002) to assist teachers with: reflecting on current classroom practices; generating a professional language; designing curriculum and learning experiences; and making intelligent decisions about individual students' needs. Therefore, the classroom observation checklist was used by the observers as a basis for discussions about their

views of teaching and learning process. Also the observations were used to examine whether the teacher taught all of the students (regardless of background), engaged in intellectually challenging and relevant curriculum in a supportive environment and whether his or her teaching and assessment practices support or hindered this.

To increase the authenticity of the observation data, and to allow the teachers to reflect on their teaching, I also collected visual information using a video camera. The video camera was used to portray what was happening in the classroom as a whole. In most cases, it was placed at the front of the classroom; however, I moved the position of the camera once every two weeks to record students' learning activities and engagement in detail. These visual data were later recorded using a student observation checklist to help with the analysis (see Appendix 6 for a copy of the checklist). As well as a measure of student engagement, these visual data were used for data analysis and to help the teachers to understand what was happening in their own lessons so that they could better judge the usefulness of the Productive Pedagogies framework in the teaching and learning of mathematics.

In addition to the use of a video camera, the teaching and learning activities were recorded using field notes made by the observers during the lessons. These field notes included, along with the observations, the feelings, thoughts and questions that arose at the time.

3.6.2 Interviews

To complement the observation data collected to evaluate the impact of the implementation of the Productive Pedagogies framework I collected data using focus-group and in-depth interviews. The focus-group interviews were conducted with both students and teachers, while the in-depth interviews were conducted with students. Section 3.6.2.1 describes an overview of the interviews with students and Section 3.6.2.2 provides an overview of the interviews with teachers.

3.6.2.1 Interviews with Students

In this study, both focus-group and in-depth interviews with students were used to explore their impressions, opinions and perceptions of the students to help to examine the impact of using the Productive Pedagogies framework on students' engagement (Research Aim 3). Morgan (1998) purports that focus-group interviews are a way of listening to people and learning from them and, according to Shank (2006), focus-groups are most useful for examining complex understandings of notions in a setting where the sharing of experiences can help to guide the other participants to greater awareness. In this study, focus-group interviews were considered useful as they were likely to be less confronting for the participants than individual interviews, thereby increasing the likelihood of them sharing their experiences. My focus-group interviews involved groups of four to six participants, as recommended by Cresswell (2008).

My focus-group interviews were also used to examine changes in students' engagement during mathematics lessons as indicators of the impact of the program (Research Aim3). The interviews were used to provide information related to: the situations that influenced the feelings, attitudes, and behaviours of students; what students believed and why they behaved in the way that they did (explaining the reasons behind the reactions); and, students' concerns, experiences and attitudes related to the program. Questions asked included: Do you like mathematics? Why? Were you comfortable learning mathematics in a way you did? Why? How was your previous mathematics learning situation? Which way was easier for you to understand the content of the lessons? Why?

In addition to focus-group interviews, I also conducted in-depth interviews with students. These interviews were used to confirm experiences, thoughts, opinions and perceptions of students that was difficult to tap into during focus-group interviews. In-depth interviews were also used to help me to understand of the world from the subjects' point of view and to unfold the meaning of the students experiences (Kvale, 1996) as the Productive Pedagogies framework was implemented. According Boyce et al. (2006) in-depth interviews are useful when detailed information about a person's thoughts and behaviours are required or when there is a need to explore new issues in depth. These interviews were used to help to explain the data collected using videos to provide a more complete picture of what happened and why. Furthermore, combining focus-group interviews and in-depth interviews formed part of my mixed methods research strategy, as each type of interview provided complementary information that could be triangulated (Millena et al, 2008).

The in-depth interviews were semi-structured, allowing me the flexibility of a conversation type interview, as well as ensuring a degree of consistency across the interviews. Using semi-structured interviews allowed me to prepare the questions ahead of time and for the participants to freely express their views in their own terms, whilst providing reliable, comparable qualitative data. Sample questions used to guide the interviews are provided in Appendix 7.

Both focus-group and in-depth interviews with students were used depending on the needs or questions at the time, and they were conducted after completing each action research cycle (usually every three and four weeks). Therefore, the interviews were conducted at least three times with each student or group of students over the course of the program. Both focus-group and in-depth interviews were conducted and audio recorded by me, as the researcher.

3.6.2.2 Interviews with Teachers

Focus-group interviews were held with each of the four teachers to provide information about the teachers' experiences and perceptions of the program and whether their knowledge and skills, related to their teaching, had improved. As well, the interviews sought to examine contextual factors that might promote or hinder the implementation of the ideas presented during the program. The focus-group interviews were used to gather information related to the development, implementation and evaluation of the program from the teachers' perspectives, as well as to gain an understanding of the teachers' perceptions of the challenges (Research Aim 1) and usefulness of the Productive Pedagogies framework (Research

Aim 2). The focus-group interviews with teachers were conducted once every three weeks for thirteen weeks and, for all interviews, all four of the teacher-participants were involved. Sample questions used to guide the interviews with teachers are provided in Appendix 8.

With respect to recording, transcribing and verifying, I ensured that all of the participants were fully aware of the process entailed in the interviews, transcription and subsequent data analysis. They were all offered an opportunity to confirm their consent to use of the recording, following a recorded interview or prior to data analysis commencing. For audio as well as video recordings, the participants were fully informed of the process. The accuracy of the interview transcripts were verified by them before the analysis was complete. As with group recordings, individuals were also given an opportunity to review, edit, or even erase their contribution on a written transcript of the recording. In all transcripts, I identified the interviewees by a code rather than by name. Transcription was undertaken by myself, as the researcher, to avoid compromising the data security and participants' privacy.

3.6.3 Reflective Journals – Teacher and Researcher

All of the teachers were asked to keep a reflective journal as a means of considering and analysing the progress of their attempts to incorporate the Productive Pedagogies framework. The teachers' reflective journals were used by teachers to record the development of their ideas related to teaching, learning and the topics that they were teaching. They also were asked to record their reflections about the subject content and their personal experiences and thoughts about their experiences of the learning

processes used for their self-development. The teachers wrote in their reflective journal after every lesson.

I also kept a research journal that included critical and analytical views of the teachers work and progress. My journal included my personal reflections on the teachers' work and how it was progressing. The research journal was used to record informal conversations with the teachers and other stakeholders (such as principals). I also used the researcher's journal during my observations of the lessons, and included my personal reflections on classroom observations (on actions, in actions and for actions).

3.7 Data Analysis

Merriam (2009) states, that data analysis is the process of making sense of the data in order to address the research questions. As such, the data analysis in this study involved organising what I had seen, heard and read, whilst referring to the research aims.

Prior to the data analysis, all recorded results were transcribed, by me, and verified by the teacher-participants. Data collected during classroom observations (supported by video recording and field notes) were categorised and analysed with respect to the Productive Pedagogies framework and the research aims. Students' impressions, comments and opinions about the implementation of the program, obtained from focus-group and in-depth interviews were grouped together based on their responses and with respect to the research aims. The interviews were conducted and analysed

in the Indonesian language. After the data analysis, all of the relevant quotations and other evidence were translated into English. The results of both focus-group and in-depth interviews were categorised and analysed based on the types of responses and with respect to the research aims. The samples of students' work were analysed descriptively to better understand the development of students' mathematical knowledge, their engagement in learning mathematics and the development of student awareness about social justice through mathematics.

As recommended by Merriam (2009), analysis of the data was carried out throughout the study, and commenced while the data were being collected. I used N-VIVO software to store, categorise, code and retrieve data for analysis. Shank (2006) states that N-VIVO software is one of the more commonly used programs currently being used for qualitative research analysis. The data collected throughout the study were stored in separate folders according to the type of data. My analysis of the data involved the use of open and focused coding, to find patterns and meaning in the collected data as guidance in connecting the study's findings and the research aims. Further, the initial emergence of key themes related to the practices and the influences on practices, which were derived from the summaries, were examined further by revisiting the transcripts for supporting as well as contradictory evidence from specific examples given by the teachers.

Analysis and interpretation of the data involved the following steps (as recommended by Creswell, 2008): preparing and organising the data; exploring and coding the data; using codes to build description and themes; representing and reporting findings;

interpreting findings; and validating the accuracy of the findings. Each of these steps is described below.

3.7.1 Preparing and Organising the Data

The scientific process is enhanced by managing and sharing research data and, according to Eyden et al. (2011), good data management practice allows reliable verification of results and permits new and innovative research built on existing information. The data, gathered through classroom observations, focus-group and in-depth interviews, as well as video recording and field notes were organised into folders based on the type of data, time of collection of data and schools from which the data originated. In order to be familiar with the data, I myself transcribed the focus-group and in-depth interviews data, from audiotapes in particular.

3.7.2 Exploring and Coding the Data

After preparing and organising the data, I explored the data and started the initial coding, by reading the transcripts in their entirety, several times, to get a sense of the whole before breaking it into parts and build descriptions and themes. As suggested by Merriam (2009), I read and re-read the data, making notes in the margins, commenting on the data in order to construct a set of tentative categories or themes. Coding of each document was then treated, not as a list of concepts but, rather, involved interaction with data and comparisons between the data. Merriam (2009) suggests that the best way to analyse qualitative information is to do it simultaneously with data collection. As such, I started analysing the data during the

data collection process to provide a more intensive analysis. The second step involved coding the data. This step was focused on building themes and categories and helped to identify significant and frequent codes. The coding at this stage, used the research aims as a guide.

As the themes developed, I assigned a working definition to each code, while going through the transcripts. In some cases, new codes were developed because the properties did not fit the text; also codes that were rarely used were dismissed. Further, I listed a number of codes and re-examined the data to see whether new codes would emerge. After this step, a constant comparative method was used to look for similarities and then differences between the themes and categories. Moreover, I reduced the codes to a small number of themes and categories of the data in order to develop a theory and bring the data back together again in a coherent whole. In short, the process of data analysis in this study began with the construction of themes and categories in a highly inductive form, then ended with a slightly deductive mode as I re-examined the data to find more evidence to support my findings.

3.7.3 Using Codes to Build Description and Themes

In this step, I continued to describe findings and focused on forming the themes or categories. For example, the theme of students' engagement in learning mathematics covered the domains of cognitive, affective and behaviour and the theme of the teachers' perceptions of the implementation of the program covered curriculum design, teaching strategies, learning assessment and classroom management. During

this process, I identified the most significantly and/or frequently used codes (Charmaz, 2006). I continued to create codes and then re-examined the data to see whether new codes emerged. After this step, a constant comparative method was used to look for similarities and then differences between the categories. Thorne (2000) argued that this strategy involves taking one piece of data (one interview, one statement, one theme) and comparing it with all others that may be similar or different in order to develop conceptualisations of the possible relationships between various pieces of data. Additionally, as the themes developed, I assigned a working definition to each code; in going through the transcripts and the themes, selected quotations were translated into English. Furthermore, I reduced the codes to a small number of themes in order to develop a theory and bring the data to a coherent whole.

3.7.4 Representing and Reporting Findings

After coding the data and using the data to build descriptions and themes, I displayed the findings in tables and figures and constructed a narrative to explain what I had found in response to my research aims. Miles and Huberman (1994) suggest that qualitative researchers often display their findings visually by using figures or pictures that augment the discussion. In this regard, I reported what I had found by using tables and diagrams to describe events and changes, using participants' views to challenge accepted and hidden assumptions and how participants are empowered (Creswell, 2008). I also considered the narrative elements that go into reporting the research findings by reporting quotes from interview data and observations of individuals, and multiple perspectives and contrary evidence.

3.7.5 Interpreting Findings

I continued to interpret findings by stepping back to construct a wider meaning, based on personal views and comparisons with past studies. Qualitative research is interpretative research, so as the researcher I needed to make sense of the findings (Creswell, 2008). As Lincoln and Guba (1985) state, such interpretation involves making sense of the data or "lessons learned". In addition, I undertook a review of major findings and the research aims that were answered; my personal reflections regarding the meaning of the data; my personal views compared or contrasted with the literature; the limitations of the study; and suggestions for future research, as suggested by Creswell, 2008, and reported further in Chapter 5 of this thesis.

3.7.6 Validating the Accuracy of the Findings

As the final step in the process of analysing and interpreting the data, I validated the accuracy of the research findings. I used a member check as respondent validation to improve the accuracy of the research findings. The member checks were intended to decrease the incidence of incorrect data and the incorrect interpretation of data. In my member checks, the interpretation was given to the teacher-participants in order to check the authenticity of the responses. Their responses served as a check on the accuracy of my interpretations. I used the member check during the interview process with the teachers in order to obtain honest and open responses. During the interviews, I restated and summarised the information for each question and asked the teacher-participants to determine the accuracy of my interpretations. They were allowed to critically examine the findings and comment on them and to affirm that

the summaries reflected their views, feelings, and experiences, or that they did not reflect these experiences. Yin (2011) points out that, for all kinds of research, including qualitative research, possibly the key quality control issue deals with the validity of a study and its findings. A valid study is one in which the data have been properly collected and interpreted, so that the conclusions accurately reflect and represent the real world (or laboratory) that was studied. Validating the accuracy of the findings in this research involved determining the credibility of the findings through a number of strategies, the means for which are described in the next section.

3.8 Trustworthiness of the Research

The most important issue in evaluating the rigour of qualitative research is trustworthiness. Throughout the process of the collection and analysis of data, I referred to the work of Guba and Lincoln (1989) and the recommendation of Yin (2011) to ensure the trustworthiness of the research. I used Guba and Lincoln's criterion of trustworthiness as one of the three approaches that are appropriate to the fourth generation evaluation, which embraces credibility, transferability, dependability and confirmability (Guba & Lincoln, 1989). I also used Yin's recommendation of building trustworthiness and credibility of the research by embracing transparency, methodic-ness and adherence to evidence (Yin, 2011).

How I addressed each of these criteria is described below.

3.8.1 Credibility

To increase the credibility of the research, I used one of the fourth generation evaluation principles, espoused by the credibility criterion. The *credibility* criterion deals with the question "how congruent are the findings with reality?" to promote confidence that the researchers have accurately recorded the phenomena. Credibility is parallel to internal validity in quantitative research (Guba & Lincoln, 1989) and is assured by involving a number of criteria including: prolonged engagement; persistent observation; peer examination; member checking; and triangulation. This idea is similar to Yin's recommendation of *transparency*. According to Yin (2011) transparency for building trustworthiness and credibility is dependent on the research procedures being carried out in a publicly accessible manner. With this in mind, I described and documented my qualitative research procedures so that other people could review and understand them. As suggested by Yardley (2009), the final study should be able to withstand close scrutiny by others. The followings points describe how I addressed the *credibility* criterion in my study:

- Prior to the study I spent some 15 weeks building relationships and trust with my teacher-participants. This helped me to better understand their needs and enabled them to better understand the goals of the program in this study (prolonged engagement);
- I conducted a sufficient number of classroom observations to enable me to identify and assess the relevant factors of the problem being pursued (persistent observation);
- I involved other teacher-participant(s) as critical friends to discuss the findings and conclusions of the study (peer examination);

- I gave all four of the teachers numerous opportunities to review the results of their own observations - such as showing and confirming the transcripts - and asked them to verify if they had any objections prior to data analysis commencing and I also discussed the results of the study with them (member check);
- In addition to using classroom observations, focus-group interviews and in-depth interviews, I also used other sources such as information and comments from school principals, school administrators, parents and colleagues to compare and cross check the data in order to improve the validity of the research (triangulation). During the analysis stage, the feedback from these additional sources was integrated to develop a broader and deeper understanding of the issues arising from this study.

3.8.2 Transferability

The second quality criterion of fourth generation evaluation that was used in this study was *transferability*. Transferability is concerned with the provision of background data to establish the context of the study and a detailed description of the phenomena in question in order to allow comparisons with other studies to be made. According to Guba and Lincoln (1989) transferability is parallel to the external validity or generalisability used in quantitative research. Furthermore, to ensure transferability in constructivist or interpretative studies, it was recommended that I provide rich descriptions to enable other researchers who are interested in this approach in their studies to reach a conclusion about whether this is a possibility (Guba & Lincoln, 1989). Therefore, in my research, I made every attempt to provide

sufficient supporting information related to the processes used in the study by describing, in detail, the collection and interpretation of the data as well as providing notes from the classroom observations.

The notion of *transferability* is similar to Yin's *methodic-ness*. According to Yin (2011) methodic-ness is important to ensure that the research is conducted in a way that is methodical. That is, there needs to be an orderly set of research procedures that minimise whimsical or careless work, to ensure a rigorous field routine. Therefore, I was careful to avoid unexplained bias or deliberate distortion in carrying out my research and brought a sense of completeness to my research efforts, as well as cross-checking the study's procedures and data interpretation. As Eisenhart (2006, p. 574) notes, fieldwork descriptions should show that a researcher was "really and fully present – physically, cognitively, and emotionally – in the scenes of action under study".

3.8.3 Dependability

In addition to credibility and transferability, I also used the criterion of *dependability* which is related to the employment of overlapping methods and an in-depth methodological description to allow the study to be repeated. Dependability is parallel to *reliability* in quantitative research in that it is concerned with the constancy of the data over time (Guba & Lincoln, 1989). There are close ties with credibility and dependability, as in practice, a demonstration of the former goes some way in ensuring the latter.

The criterion of *dependability* is similar to Yin's *transparency*, in which the research is carried out in a publicly accessible manner. To address this issue, I kept research notes or journals throughout the study so constructing an audit trail by providing the details of the research process including the collection, analysis and interpretation of data accumulated during the study.

3.8.4 Confirmability

The last criterion that I used was *confirmability*, which deals with triangulation of data, and is used to reduce the effect of investigator bias. Confirmability addresses: the admission of researcher's beliefs and assumptions; a recognition of shortcomings in the study's methods and their potential effects; and an in-depth methodological description to allow the integrity of the research results to be scrutinised. Confirmability is parallel to *objectivity* in conventional research; in that it refers to the degree to which the outcomes of the study can be confirmed by others (Guba & Lincoln, 1989).

This principle is similar to Yin's *transparency*, in which the research procedures are required to be transparent so that other people can review and understand them. Therefore, in this, and other chapters, I provide sufficient information to confirm the accuracy of the research procedures so as to assure the integrity of the findings. Further, the data (constructions, assertions and facts) can be tracked to their sources, and the logic used to assemble the interpretations which are made structurally coherent. Confirmability is also parallel to *adherence to evidence*. Yin (2011) suggests that research should be based on an explicit set of evidence. With this in

mind, Willig (2009) argues that in a research study participants should be able to express their decision making process and that the evidence will consist of participants' actual language as well as the context in which the language is expressed. Therefore, all analysis was conducted in the original participants' language (Bahasa Indonesia) and only later was the English version introduced to ensure a true representation of reality.

To summarise, throughout the process of the collection and analysis of data, I referred to the work of Guba and Lincoln (1989), which embraces credibility, transferability, dependability and confirmability, and the recommendation of Yin (2011), by embracing transparency, methodic-ness and adherence to evidence, to ensure the trustworthiness of the research.

3.9 Addressing Ethical Issues

In order to protect the individuals who participated in this research, appropriate ethical considerations were made. It was one of the requirements of Curtin University's policies for students of a post graduate degree to obtain an ethics clearance at the time of their application for candidacy. The approval number of ethics clearance for this study is SMEC-04-12. A copy of the letter can be found in Appendix 9.

A researcher needs to inform the participants of what the study will involve so that they can make an informed decision about whether or not to participate (Hammack, 1997). Prior to the implementation of the research, I informed all of the participants

of the purposes, benefits, risks, methods and possible outcomes of the research. Moreover, all participants were asked to sign an informed consent form before they participated in this research. A copy of the information sheet and consent forms for students, teachers and principals can be found in Appendix 10, 11 and 12, respectively.

Creswell (2008, p. 157) states: "It is important to protect the privacy and confidentiality of individuals who participate in the study". Therefore, the participants in this study were assured of their anonymity and the confidentiality of their responses. As the researcher, I respected the privacy of the participants, but anonymity is difficult to guarantee in action research. Therefore, I concealed the participants' names as well as the names of the schools by using pseudonymous. Further, all responses of participants were anonymous and treated confidentially. According to Mills (2007), confidentiality is evident when the researcher knows the identities of participants but promises not to release them to anyone else.

The nature of this research was voluntary. Therefore I gave all the students and the teacher-participants the option to be involved in the research study. Furthermore, participants who had agreed to be involved in this study could withdraw from the research at any time without reason or penalty. I also informed the students that their participation would not affect their grades.

3.10 Chapter Summary

The research reported in this thesis involved four teachers implementing the Productive Pedagogies framework using an action research methodology. Action research, a collective self-reflective enquiry, was used as a means for the teachers to improve their own educational practices. The action research involved a repeating spiral of three stages, namely, planning, action and observation, and reflection.

The two schools from which the teacher-participants were selected were located in the Lembang County, West Java, Indonesia. Two of the teachers were teaching at a public school located in an urban area (State Junior High) and two were from a private school located in a rural area (Mekarsari Junior High). The rural school was populated with students from a low socioeconomic background whilst the urban school was populated with students from a higher socioeconomic background.

The teacher-participants all were teachers of Year 7 mathematics whose experienced ranged from between 10 and 25 years. The class sizes ranged from 23 to 30 students and, as the class groupings were not based on ability, it was assumed that a range of abilities would be represented in each of the classes.

Prior to the implementation of the Productive Pedagogies framework, a five-day work shop was held to familiarise the teachers with the research and the framework that they would be implementing. The implementation of the framework, as described earlier, involved three action research cycles, during which the teacher-participants were supported by me, the researcher.

Data were collected using classroom observations and interviews. A minimum of two classroom observations, for each teacher, were carried out every week. The teachers were observed by me and the other teacher who taught at the school. Non-participant observations involved the use of an observation guide, developed specifically to monitor the introduction of the Productive Pedagogies framework. Observations were recorded as field notes and using a video camera. These video recordings included recordings of students (at least once per week) that were later analysed to determine whether student engagement improved over the three action research cycles.

Interviews were held with both teachers and students. The interviews with students involved both focus group interviews and, when appropriate or necessary, in-depth interviews. Focus group interviews were held with teachers throughout the three action research cycles. All interviews were audio recorded and transcribed verbatim for analysis.

Data analysis was carried out throughout the study, and commenced while the data were being collected. The analysis of the data involved the use of open and focused coding, to find patterns and meaning. The process for analysing and interpreting the data involved preparing and organising the data, exploring and coding the data, using codes to build description and themes, representing and reporting findings, interpreting findings and validating the accuracy of the findings.

The trustworthiness of the research was evaluated throughout the research (as recommended by Guba and Lincoln and Yin, 2011). I used the criterion of

trustworthiness as one of the three approaches that are appropriate to the fourth generation evaluation, which embraces credibility, transferability, dependability and confirmability and the recommendation of building trustworthiness and credibility of the research by embracing transparency, methodic-ness and adherence to evidence.

Finally, this chapter described ethical considerations made to protect the individuals who participated in this research. The study was given an ethics clearance to protect the individuals who participated in this research. In addition, prior to the implementation of the research, I informed all participants of the purposes, benefits, risks, methods and possible outcomes of the research. To respect the privacy of the participants, I concealed the participants' names as well as the schools' names by using pseudonyms and all participants' responses were anonymous and treated confidentially.

Chapter 4
RESULTS AND DISCUSSION

4.1 Introduction

The aim of the research reported in this thesis was to evaluate the implementation of the Productive Pedagogies framework as a means of reforming teaching in mathematics classes in Indonesia. This implementation was carried out in the classes of four mathematics teachers, over three action research cycles, each lasting approximately one month. The findings are organised into four parts, according to the four research aims. First, the challenges that confronted the teachers as they implemented the Productive Pedagogies framework is reported (Section 4.2). Second, the effectiveness of using the Productive Pedagogies framework as a guide for reflection on teaching is described (Section 4.3). Third, the effectiveness of the Productive Pedagogies framework, in terms of, improved classroom interactions connectedness and social justice is reported (Section 4.4). Finally, the findings related to student engagement are reported (Section 4.5).

4.2 Research Aim 1: Challenges of Implementing the Productive Pedagogies Framework

Over the course of the three action research cycles, the teachers used the Productive Pedagogies framework to assist them in improving their teaching. The teachers generally agreed that the dimensions of the Productive Pedagogies framework and the elements associated with these were important. However, classroom observations

indicated that the implementation of the framework was carried out with varying degrees of success. Although all of the teachers attempted to include the elements in each of their lesson plans, observations indicated that the elements were not always used in their teaching and, when they were, it was with varying degrees of success. Table 4.1 provides, for the third action research cycle, a summary of the number of lessons in which each element was written into a lesson plan and the number of lessons in which the element was observed. Finally, the table reports the degree of success with which each of the elements was implemented by each of the teachers. This final score was based on the analysis of the observation sheets, and involves a scale of one to ten. A score of one indicated that the attempt was met with no success and a ten indicated a perfect attempt.

The results, reported in Table 4.1, indicated that the teachers were more likely to focus on elements within the Connectedness and Supportive Classroom Environment dimensions than on the elements within the Intellectual Quality and Recognition of Difference dimensions. The table shows that, within the Connectedness dimension, the teachers tended to focus on the elements of *knowledge integration, background knowledge* and *connectedness to the world,* rather than *problem based curriculum,* which was not used or implemented as often. For the Supportive Learning Environment dimension, two of the elements, *student direction* and *social support* were frequently observed in the classes of all of the teachers but the remaining elements were not. The results also suggest that, of all of the dimensions, Intellectual Quality was the least likely to be included either in lesson plans or observed in classes.

Table 4.1 Attempts and Success at Implementing the Productive Pedagogies Framework In the Third Action Research Cycle

Element	**Teacher**											
	Nurjanah			**Yanti**			**Yayu**			**Wawan**		
	**Attempts*		*Success*	*Attempts*		*Success*	*Attempts*		*Success*	*Attempts*		*Success*
	P	O	**	P	O	**	P	O	**	P	O	**
Intellectual Quality												
Higher-order thinking	7	6	7	6	5	6	5	4	6	5	4	5
Deep knowledge	6	5	6	5	4	5	5	4	5	4	4	5
Deep understanding	6	6	7	5	4	6	5	4	5	4	3	4
Substantive conversation	8	7	8	7	6	7	7	6	7	7	5	6
Knowledge as problematic	5	4	5	5	4	5	4	4	5	4	3	4
Metalanguage	7	6	7	5	5	6	6	5	6	6	4	5
Supportive Classroom Environment												
Student direction	8	8	9	8	7	8	7	7	8	7	6	7
Social support	8	8	9	8	8	9	8	7	8	8	7	8
Academic engagement	8	7	8	7	7	8	7	6	7	7	5	6
Explicit quality performance criteria	8	8	8	7	7	8	7	6	7	7	6	7
Self-regulation	8	8	8	7	7	8	7	6	8	6	5	7
Recognition of Difference												
Cultural knowledge	7	6	7	7	5	6	5	5	6	5	4	5
Inclusivity	8	7	8	6	5	7	6	6	7	6	5	6
Narrative	6	5	6	5	4	5	5	5	6	5	4	5
Group identity	7	7	8	5	5	6	5	4	5	4	3	5
Active citizenship	7	6	7	7	7	8	6	4	5	5	5	6
Connectedness												
Knowledge integration	8	8	9	8	7	8	7	7	8	7	6	7
Background knowledge	8	7	8	8	7	8	7	6	7	6	6	7
Connectedness to the world	8	8	9	7	7	8	7	6	7	7	6	7
Problem-based curriculum	7	6	7	5	5	7	5	4	5	4	3	3

Note: - There were 8 lessons for each class/teacher over the last action research cycle (3rd cycle)
- * *Attempts* column consists of the number of times that the elements were incorporated into lesson (P) and the number of times the element was observed (O)
- ** Scale of 1 – 10 with 1 being not successful and 10 being very successful
- P = Planned and O = Observed

The results reported in Table 4.1 also suggest that two of the teachers, Yayu (from State Junior High) and Wawan (from Mekarsari Junior High) were less likely to incorporate the individual elements into their lesson than Nurjanah (from Mekasari Junior High) or Yanti (from State Junior High) and they also experienced the least success when implementing the elements. Of note, is that, by the third action

research cycle, Nurjanah was attempting to incorporate almost all of the elements into her lessons and was experiencing a high degree of success.

Analysis of the data indicated that there were a number of challenges faced by all of the teachers that influenced the degree to which they were successful. These challenges included changing from their traditional beliefs (Section 4.2.1), understanding and implementing the elements (Section 4.2.2), student involvement (Section 4.2.3) and time constraints (Section 4.2.4). This section reports the findings for each of these.

4.2.1 Changing from Traditional Beliefs

All of the four teachers studied, intensively, the Productive Pedagogies framework at a workshop held over a five-day period (as described in Section 3.4.3). The aim of the workshop was to provide convincing evidence and the means by which teachers could shift their teaching from a traditional to a constructive teaching style of teaching. The workshop was focused on changing the teachers' mind-set (mental attitude or disposition) from an existing and well known teaching paradigm, which has been used for many years (and in which the teachers had faith), to a framework that was, as yet, untested in the Indonesian context. It was hoped that shifting their mindset would influence their responses to and interpretations of the challenges that arose as they implemented the various elements.

For teachers to move from their traditional approach of teaching, they needed to be convinced of the advantages of the new paradigm and shown evidence of its success

in relation to teaching practices. Unfortunately, because Productive Pedagogies framework was a relatively new teaching model evidence of its successful was rather limited. Although it had been used in Australia and other countries (Alsharif, 2011; Tanko, 2012; Alhosni, 2013; Bature, 2014), as far as I was aware, it had not been used in Indonesia previously.

To help the teachers to make the shift, they studied together, with me, each of the elements to help them to understand their importance and how they applied to the teaching of mathematics. Convincing the teachers of the importance of these elements required going back to principles of teaching that they have covered when they were studying to become teachers. It was necessary to link the Productive Pedagogies framework's elements to these principles so that they could critically examine the paradigm from which they were teaching and what they understood as good teaching practice, both of which ignored these principles.

Initially, the teachers were somewhat resistant to the Productive Pedagogies framework. It would appear that this was because they felt that the ideas of the framework came from 'the West', and incorporated aspects of Western culture that were different from the Indonesian culture. For example, Yanti stated, "I can see that this teaching framework might be successful in Western schools but I am not sure this framework will get the same success if applied in Indonesia" [Focus-group interview and during five-day workshop]. Shifting this view required sharing, with the teachers, non-western perspectives on the elements of the Productive Pedagogies framework, for example, the works of Paolo Freire with his Critical Pedagogy, wherein many of the Productive Pedagogies framework elements can be found.

Teachers also felt that some of the elements were not appropriate for use in the Indonesian education system. For example, in Eastern culture, particularly in Indonesia, a teacher is recognised as having a high status and therefore, respected by everyone and, in particular, by their students. In Indonesian classrooms, teachers tend to determine and control teaching and learning activities; with students being required follow the instructions of the teacher. Therefore, applying, for instance, the element of *student direction*, in which students are encouraged to be involved in determining learning activities, and even the learning outcomes, was both unusual and strange to the teachers. As Nurjanah pointed out, "I can see that Productive Pedagogies is a good framework for better teaching, but I feel that not all elements suitable to schools in Indonesian culture. For example, the elements of Intellectual Quality dimension such as the metalanguage and knowledge as problematic elements are complex and not easily applied to mathematics teaching" [Focus-group interview].

As the teachers started to implement the various elements into their classrooms, they experienced a number of challenges, particularly with respect to student behaviour. In some cases, if the teachers were unsure or their instructions unclear, the students became off task (for example, talking with other students). In other cases, the teachers experienced problems in terms of getting the students to pay attention or to concentrate on the activity at hand. These challenges meant that, when the teachers experienced difficulty in implementing an element in their lesson, they reverted to the traditional method of verbal discipline to regulate students' actions and movements.

The implementation of the Productive Pedagogies framework involved a challenging and complex transition task for the mathematics teachers, in which they were expected to make a bridge from their old beliefs about teaching to this newer paradigm. During the action research cycles, remarkable breaks from traditional teaching were made by teachers. For example, for the first time Wawan, did not lecture but, rather, gave a number of assignments with similar themes to students working in groups. During the lesson he expected students to share their ideas while he encouraged them to maintain dialogue and to express their opinions. Although sceptical at first, these breaks from tradition gave the teachers the opportunity to see the benefits of incorporating this different style of teaching and, as a result, significantly helped to change the way that they felt about implementing elements of the Productive Pedagogies framework into their teaching. This reflection on successes served to encourage the teachers to take more risks in their practice. Changing teachers' mindset was a gradual process and the process of observing and reflecting as they implemented the various elements helped them to better understand the values of changing their teaching style.

4.2.2 Understanding the Elements

Another challenge that hindered the implementation of the Productive Pedagogies framework was the teachers' understanding of what the individual elements looked like in practice. Even though careful introduction of the elements helped to convince the teachers of their usefulness, the teachers were not always clear about how they might be translated into their teaching. This was particularly so for the elements of

higher order thinking, *deep knowledge*, *deep understanding* and *knowledge as problematic*, as explained below.

For the elements of *higher order thinking*, *deep knowledge*, *deep understanding*, *knowledge as problematic* (from the Intellectual Quality dimension), *academic engagement* (from the Supportive Classroom dimension), *group identity* (from the Recognition of Difference dimension) and *problem-based curriculum* (from the Connectedness dimension), the teachers' lack of understanding became evident during classroom observations. These observations indicated that, even though the element was written into their lesson plan, it was either not observed or alternatively, not implemented correctly. For example, one of the teachers, Yanti, regularly provided mathematical problems that included real-life examples in her lessons (to support the *problem-based curriculum* element). Although the problems were solved by students in their groups, the teacher only accepted one, single, correct solution. Yanti did not deviate from this solution or explore alternative solutions.

In other cases, the teachers' lack of understanding of the elements led them to use activities that were not appropriate. For example, I observed two teachers, Yayu and Wawan, attempting to use short stories to introduce their mathematics lessons (to support *background knowledge* and *connectedness to the world* elements). In both cases, the teachers' stories did not relate to or support the lesson content that followed. For example, Yayu introduced a lesson about equivalent fractions using an illustration of two routes that she could use to get from her home to the school. She explained that, for one route, her motorcycle used two litres of fuel and, for the other route, the motorcycle used three litres of fuel. Although her illustration was real,

actual and understandable for the students, the story was not relevant to the mathematical content of the lesson. Also, it was not useful in terms of helping the students to understand the mathematical concepts as it only compared the fuel consumption of the two routes and did not illustrate the concept of equivalent fractions.

In some cases, the teachers' lack of understanding of the elements led to them making incorrect decisions about what students needed to learn. For example, teachers' misunderstanding of the essence of two elements in the Recognition of Difference dimension, *cultural knowledge* and *narrative*, led to an assumption that, to help students in their learning of mathematics, it was necessary to omit some of the other mathematics topics from the curriculum to allow them the time they needed accomplish the element. Yanti explained that, "To help many of the students to understand the mathematical concepts within a topic using the elements of *cultural knowledge* and *narrative*, it was necessary for me to decrease my teaching time and attention on other topics" [Teaching reflection]. This meant that the remaining topics were not covered well by the teacher and, as a result, the students were disadvantaged in their coverage of these.

It would appear that the teachers' lack of understanding influenced their view of the applicability of some of the elements in mathematics teaching. For example, Yanti and Yayu both felt that the *narrative* element, from the Recognition of Difference dimension, was not applicable to mathematics because it required a linked sequence of events involving personal stories and socio-cultural texts. As such, they felt that the narrative element was more related to social studies or languages rather than

mathematics, which involved more abstract concepts. Yanti stated, "Applying the *narrative element* in mathematics teaching was difficult for me because I needed to create a link between events presented" [Focus-group interview]. It would appear that, because of the lack of understanding of its application to mathematics, the teachers were resistant to the implementation of the narrative element in their lessons, as reflected in Table 4.1.

To compound this problem, the framework lacked clear examples for teachers to follow. As the teachers had not used the framework and had previously taught only using a teacher-centred approach, the lack of examples made translating the ideas into practice difficult for them. To this end, Nurjanah said that, "It would be useful if the framework were to provide assistance to teachers to develop a range of teaching approaches" [Focus-group interview]. Yanti stated, "In order to be more applicable, we need more mathematics teaching examples that use the Productive Pedagogies framework so that we can better understand the application of this framework in our teaching practices" [Focus-group interview].

The teachers found that some of the elements were too complex to apply to their teaching, in particular *higher order thinking; knowledge as problematic; deep understanding;* and *problem-based curriculum*. Three of the four teachers found that the multifaceted nature of *higher order thinking* element made it difficult to plan dor and implement, as it involved a range of tasks (such, combining, synthesising, generalising, hypothesising mathematical ideas, developing conclusions and developing interpretations). For example, Yanti, commented: "Even though I know that applying the *higher order thinking* element in my mathematics teaching is

useful, it was difficult to do. I needed extended time to prepare this element to be effective" [Teaching reflection]. Nurjanah, although she recognised the importance of the *higher order thinking* element, also thought that incorporating it was not easy. Unlike the other three teachers, however, Nurjanah challenged herself to develop mathematics lesson that involved the *higher order thinking* element and, therefore, her classes tend to include more of this element.

Over the course of the three action research cycles, the teachers began to better understand the elements and this was reflected in the improvements made when implementing them (a point that is discussed further in Section 4.3). As their understanding improved, so did their attitudes and willingness to include the elements. For example, initially, the element of *metalanguage* was not well received by teachers but, as they began to understand it, their views changed. To this end, Yayu stated, "When I applied the *metalanguage* element in my teaching of mathematics, my students' self-confidence and motivation significantly increased, especially when they were interacting with other students" [Focus-group interview]. Nurjanah, had similar feelings, stating in her personal journal: "Previously, I did not believe that the use of *metalanguage* in the teaching of mathematics would improve students' motivation to learn but, when I was using this element in my mathematics teaching, my students became excited, especially when I used examples that were familiar to them. It really helped them get a better understanding of the mathematical concepts" [Teaching reflection]. Yanti also reflected on the growing awareness of the benefits of the individual elements, such as *metalanguage* element when she said: "Honestly, at the beginning I could not develop learning activities that applied the *metalanguage* element. I thought that this element was only suitable for language

classes. But, after I used the *metalanguage* element in my teaching I was surprised to see that the majority of students were enthusiastic to express their opinions and questions, and, as a result, they made more sense of the lesson" [Focus-group interview].

4.2.3 Challenges Related to Student Involvement

When the teachers first started to implement the Productive Pedagogies framework, a major challenge that they experienced was the students' lack of confidence and willingness to express their ideas; either as a whole class or in small groups. In the past, teachers had not communicated with the students on an individual basis and neither had they considered the students' individual abilities or interests during the programming. As a result, the teachers' implementation of the Productive Pedagogies framework required the teachers, for the first time, to negotiate with students and generate dialogue with and between students so that they would be involved in the learning activities.

The teachers felt that, in addition to students' lack of experience in expressing their ideas, the framework favoured the more outgoing West Javanese students over Sundanese students in the classrooms. Students from a Sundanese background tended to be less talkative (influencing the success of the *substantive conversation* element), preferring to be a passive recipients rather than initiators (influencing the *student control* element) and would rather be followers than leaders (influencing the *self-regulation* element). Given that the majority of the students in the classes of the four teachers were Sundanese, the teachers became aware of the need to use strategies

that would encourage them to speak out. (These strategies are described in Section 4.3.1.) Observations of lessons carried out during the first action research cycle indicated that few Sundanese students (an average of 21% of the students per class) were willing to express their opinions or make suggestions; with the majority of them preferring to listen to their peers and follow rather than initiate ideas. However, in the second action research cycle, the number of students who spoke out in class increased to an average of 45%. In the third cycle the number of students who expressed their comments, opinions and suggestions and initiated their own ideas increased still further, to an average of 69% for the Sudanese students in each class.

Another challenge faced by the teachers was the need to get students to change from an individual to a collaborative style of learning. This shift meant that, in addition to their own needs, students were required to consider the needs of group members and to work with their peers (influencing the success of the *cultural knowledge* element). This had never occurred in the mathematic classes of these teachers and the students were not used to considering or respecting the opinions of their peers, particularly when the opinion differed from their own. Students required encouragement to help them to understand that learning collaboratively required interaction between the group members.

Despite the change from individual to collaborative learning style, students who were used to expressing their opinions continued to dominate group discussions while those who were “learning” to speak out still had difficulty in voicing their ideas. Further, many of these students, who had not spoken out previously, had limited Indonesian and, therefore, lacked the confidence to give or defend their opinions and

often gave up. Overcoming this challenge required the teachers to focus on the group dynamics and to consistently remind the dominant students to, not only give opportunities to the other students to express their opinions but also to encourage them to appreciate the opinions of others. At the same time teachers were required to motivate the students, who were reluctant to speak out, to keep trying. Equally challenging for the teachers was the need to encourage the students who were not confident to defend their options in the face of more dominant and of their higher-achieving students who had traditionally been the only students who spoke out or participated in class.

4.2.4 Time Constraints

A further challenge experienced by teachers during the implementation of the Productive Pedagogies framework, was the constraints imposed on them by the educational system. Because of the large amount of content that was required to be covered in a limited amount of time, the teachers found it difficult to find the time to incorporate the ideas of the Productive Pedagogies framework effectively. For example, the teachers found that the implementation of the elements of the Connectedness dimension (to make explicit links to other subjects) could not be done adequately without exceeding the allotted time. Nurjanah asserted: “Although I am aware that mathematics is related to other subjects and that, to be effective, I should integrate the content of my mathematics lesson with other areas, I often find that I need more time” [Teaching reflection]. Similarly, Yanti stated, “There are numerous ideas, such as the element of problem-based curriculum, that would make

mathematics teaching more effective, but at the same time, these exert even more pressure on us as teachers" [Focus-group interview].

In some cases, even though teachers were aware of the benefits of incorporating the elements of the Productive Pedagogies framework, they realised that including them would place pressure on an already full curriculum. Given the time constraints, the teachers were generally in agreement that including the element of *student direction* was not practical. For example, Wawan stated: "It was hard for me to give my students control of learning activities because it takes time. I have to quickly complete the topics in the curriculum by implementing lessons and this is easier without interruptions from the students" [Focus-group interview]. Yayu, argued: "Although the Productive Pedagogies framework is a good teaching framework, we need to examine this framework in the Indonesian setting in relation to local characteristics, and we need to evaluate the outcomes of the examination in such a situation" [Focus-group interview].

As discussed previously, the Productive Pedagogies framework was developed in Australia and this was, to the best of my knowledge, the first time that it had been used in Indonesia. Although the results indicated that, in general, the teacher-participants felt that the elements of the Productive Pedagogies framework were important for improving the quality of education in Indonesia, there were a number of challenges related to the implementation of the framework.

4.3 Research Aim 2: Using the Productive Pedagogies Framework for Reflection on Teaching

Overcoming the various challenges that confronted the teachers was important if the implementation of the framework was to be successful. An important aspect of the implementation of the Productive Pedagogies framework was the requirement that teachers reflect on their teaching by reviewing the degree to which they had achieved their goals and the effectiveness of the teaching strategies that they had used. These sessions were carried out after every lesson and involved the teacher, myself (as the researcher) and the other teacher who had observed the lesson.

During classroom observations, held prior to the introduction of the Productive Pedagogies framework, I noted only three instances of teacher reflections. On each of these occasions, the two teachers, Nurjanah and Yanti, reflected alone. The two teachers each reflected on one and two lessons, respectively. The three reflections focused on one or two aspects of the teaching and learning that had taken place during the lesson (such as misconceptions which might have occurred during the teaching or how to make students more active in the learning process). None of the reflections reviewed the effectiveness of the teaching strategies that were used during the delivery of the lessons. Additionally, the reflections did not include a self-evaluation of their competences as teachers in areas, such as their understanding of mathematical concepts. By and large, the four teachers did not include self-assessment to review their lessons to improve their teaching.

An integral part of the reflection process was the observations of the lessons made by me and one other teacher. It should be noted that, prior to the introduction of the Productive Pedagogies framework, none of the teachers had experienced being observed. The initial observations indicated that teachers were somewhat stilted in their delivery, particularly at the start of the lessons, indicating that they were conscious of the observers' presence and were a little nervous. However, because the observations became a regular activity and were carried out twice a week, the teachers all became more at ease and, according to the interviews with the teachers, by the end of the first action research cycle they were no longer disturbed by the presence of the observers. Yanti reflected the views of the others when she said: "When my teaching was observed for the first time I felt clumsy and uncomfortable but I gradually adapted to this situation and I am now comfortable when my teaching is observed" [In-depth Interview].

This section starts by explaining how the Productive Pedagogies framework, in conjunction with the curriculum, was used to develop the lesson plans that promoted and focused the reflection session (Section 4.3.1). The section goes on to discuss how the Productive Pedagogies framework was used as a guide for teachers to reflect on the strengths and weaknesses of the lessons to enhance the quality of their teaching in subsequent lessons (Section 4.3.2).

4.3.1 Using the Framework to Develop Lesson Plans

The careful planning of lessons was an important stage that helped the teachers in their reflections on their teaching. As experienced teachers, the four teachers were all

familiar with developing lesson plans, however, the lesson plans developed prior to the introduction of the Productive Pedagogies framework were written to fulfil an administrative requirement. As such, they used a generic format, provided by the government, that involved statements that were more cognitive than operational (for example, 'At the end of the lesson the students will be able to understand concept of fractions'). The new lesson plans, developed using the Productive Pedagogies framework, were quite different to what they had been used to as they required the teachers to align the teaching objectives with the curriculum, determine the criteria for the quality of performance, related to the learning outcomes, and outline the teaching strategies that they would use.

For each lesson plan, the teachers used the Productive Pedagogies framework to help them to consider both the 'why' and 'how' of their teaching. The 'why' was related to the essence of the topic and required that the teachers obtain a deep understanding before they started. For example, Nurjanah, who was planning to teach the students about the use of operations when working with fractions, became cognisant of the need to have a deep understanding of the fractions and the operations that were used. In doing so, she would be better able to facilitate the students in ways that would bring about a clear understanding of the concepts. The 'how' involved making decisions about the teaching strategies that would be used to deliver the topic in ways that would effectively help the students develop the relationships among the concepts of the topic rather than reciting fragmented pieces of information.

Before determining the 'how' of teaching or the teaching strategies that would be used, it was important to clearly outline the teaching objectives for the lesson

(including the range of student performance). The Productive Pedagogies frameworks' *explicit quality performance criteria*, makes clear the need for teachers to state the learning outcomes, including what performance was considered to be appropriate both for lessons and for their homework. Outlining the performance criteria (and learning outcomes) in detail and for the various stages of the lesson involved stating, explicitly, the expected criteria for student performance. For instance, when stating the expected outcomes for the lessons, they wrote statement such as "After studying … the student should be able to …" or "The students were expected to be able to … with competence and confidence."

Once the objectives were clearly outlined, the teachers then went on to decide on how they would deliver the lesson and the teaching strategies that they would use to achieve the teaching objectives. These activities were required to focus on how to help the student to construct their knowledge (using, for example, student discussions, demonstration, and group problem solving activities). For example, when planning a lesson of fractions, Nujanah considered a number of teaching strategies before deciding to use a collaborative approach (using student discussion – in small groups) as the main teaching strategy.

Once the teachers had decided on the teaching strategies that they would use, they then developed the tasks, activities and assignments that they would present to the students. In Nurjanah's case, she decided that she would use groups of four to five students, based on their parents' occupation (for example, some groups might be made up of students whose parents were farmers). In this way, she could present a

different problem to each of the groups, tailoring the problem to suit the background experience of the students.

Once the teachers became familiar with using the Productive Pedagogies framework to develop their lesson plans, they felt that this was beneficial to their teaching. They chose which elements they would focus on while considering the topic and its objectives. As Yayu stated, "The Productive Pedagogies framework prompted me to consider why a topic needs to be taught and how the topic should be delivered in order to attain the outcome that the lesson targeted" [Focus-group interview]. Nurjanah said that, "A lesson plan is not only related to the content of a lesson, but also concerned to the strategies that ensure the content is delivered effectively. The Productive Pedagogies provides this intention" [Focus-group interview].

4.3.2 Using the Framework to Reflect on the Lesson

Using their lesson plans and the elements of the Productive Pedagogies framework the teachers reflected on their teaching after each lesson. I, and the other teacher who had observed the lesson, reflected together with the teacher. When teachers first started to reflect on their teaching, they found the sessions to be difficult and time consuming. Initially, the teachers were also uncomfortable with discussing their teaching with others as this was not something that they had done before. By the end of the three action research cycles, however, the teachers felt that reflecting on their teaching was not as difficult as they had originally thought and, despite being a considerable investment in terms of time they were generally pleased to do it. To this end Yanti reflected the views of the others when she said, "Even though our

reflection took time, they enabled us to look and evaluate our own teaching so that, in our next teaching session, we could do things better" [Focus-group interview].

The reflection sessions involved a number of steps. As a first step, the teacher who was observed used key words from the lesson objectives to examine what the students had done and the extent to which the lesson objectives had been achieved. This initial step was important as it encouraged the teachers to consider that the mastery of a topic was not determined by whether or not the topic was conveyed or delivered but, rather, by the extent to which students' mastered the topic in accordance with competencies targeted by the curriculum.

Once the teachers had examined the students' performance, in light of the lesson objectives, the reflection sessions then went on to examine the effectiveness of the teaching in terms of the individual elements in the Productive Pedagogies framework. This involved two foci, these being, the process of teaching and learning and the teaching methods and approaches that were used. For both of these it was important that the teachers reflected and identified their strengths as well as their weaknesses.

Reflecting on the process of teaching and learning involved examining everything that had happened during the lesson, both in and out of the classroom that may have influenced or supported the delivery of the lessons. These included unpredictable events that might have occurred, such as an unexpected comment from a student, or the need to change to a different, unplanned, teaching strategy. The observation checklists, made by the other teacher and myself, helped remind the teacher of these

events. For example, one unexpected event occurred during Nurjanah's lesson on fractions. The observers noted that there was some confusion from the students when Nurjanah used an illustration a birthday cake on the whiteboard and 'sliced' the cake into pieces by drawing lines on the 'cake'. One of the students, unexpectedly, raised his hand and asked the teacher whether they could use a piece of paper (to illustrate the cake) and scissors to 'slice' the cake. Nurjanah agreed and organised the distribution of paper and scissors to groups so that they could make a cake and slice it into fractions.

Reflecting on the teaching methods involved going through each of the dimensions and elements of the Productive Pedagogies framework in turn and reflecting on both the plan and the lesson. This step involved examining the elements that were used in the lesson plan and how well each was implemented. In this way, the framework gave the teacher a concrete means by which he or she could reflect on his or her teaching from different perspectives. Below is an example of how Nurjanah used the elements to reflect on her teaching after one of his lessons.

After the lesson that Nurjanah had delivered to her Year 7 students (on the topic of using operations when working with fractions), she reflected on the elements of *deep knowledge* and *deep understanding*, and acknowledged that, in a previous lesson, she had not sufficiently understood the essence behind the rule for each of the operations when used with fractions. She had since reviewed these and, as a result, changed the order that she taught the operations. That is, whereas previously, she had introduced the addition of fractions first (which involved finding a common denominator and was somewhat confusing to the students) in this latest lesson she had started with the

division of fractions then gone on to multiplication, addition and, finally, subtraction. In her reflection, Nurjanah felt that this most recent lesson was more successful because the students had experienced a degree of success before going on to more challenging problems.

When Nurjanah examined the elements of *deep knowledge* and *deep understanding*, she noted that the collaborative nature of the task that she had used required extended dialogue between the students to develop shared ideas. Nurjanah had attempted to limit the amount of direction that she gave to them. For example, during the whole class session of the lesson (in which the students presented their solutions and commented on each other's findings), she was pleased that she had been able to encourage students to discuss their ideas but had not directed these discussions in any way.

However, when reflecting on the element of *substantive conversation*, Nurjanah realised, during the reflection, that she had not fully understood this element. The element of *substantive conversation* focuses on the promotion of interactions among the members of the classrooms so that they are able to enable the sharing of ideas and learning experiences related to the subject matter (such as applying its ideas and making generalisations about the concepts). However, Nurhanah had assumed that this element involved students sharing facts or procedures. Further, although Nurjanah had encouraged dialogue between the students and herself, she felt that she had not directed the dialogue sufficiently to make the concepts clear to the students. In this respect, she felt that she needed to better understand this element and requested that we work on this in the future.

When examining the element of *cultural knowledge,* Nurjanah's expressed that she was not happy with the illustration that she had used to help the students to understand fractions. In this lesson, she had used a birthday cake to illustrate the different operations (add, subtract, multiply and divide) and how these might look. Upon reflection, she realised that the use of a birthday cake was not a good example because most of her students were from disadvantaged backgrounds and, therefore, did not have birthday parties and were not familiar with a birthday cake. She decided that, in future, she would provide more meaningful examples.

When examining the element of *background knowledge,* Nurjanah felt that she had implemented this well as she had placed students in groups based on their parents' occupations (as described previously). The problems that she had provided to each group were related to the parents' occupation s (e.g. farming) and, as such, they were meaningful. However, when discussing the element of *problem-based curriculum* Nurjanah felt that she had not implemented this element well. She felt that, although the problems she had set were challenging, in some cases, they were possibly too challenging and, as a result, the students' had become frustrated. In this case, some of the problems involved adding the parts of the cake with different denominators (for example, one fifth add three quarters) and these were, in hindsight, too complex for some students. She acknowledged this, saying that, in future lessons, she would pay more careful attention to the structuring of problems for different ability students.

Based on these reflections, Nurjanah examined more closely how she could implement the elements of the productive pedagogies more effectively. In some

cases, she made changes to the way in which she implemented the strategies and, in other cases, she made a conscious effort to better understand the elements and how she could apply them to her teaching. In the case of the latter, Nurjanah sought help from me and I was able to provide her with extra help.

By reflecting on their lessons, using the dimensions and elements of the Productive Pedagogies framework, teachers were given an opportunity to evaluate their strengths and weaknesses. By using the elements of the framework, teachers were able to examine the lesson from a different perspective. In this way, teachers were able to comprehensively and routinely review their lessons. Of this, Nurjanah said that, “reviewing the lesson allowed me to look my own teaching and to identify the strengths and weaknesses of my teaching” [Teaching reflection]. She went on later to add, “As a teacher, I need to reflect on my teaching in order to improve my next lesson” [Teaching reflection].

In short, all four teachers applied the elements of the Productive Pedagogies framework to reflect their teaching by using different perspectives such as considering what is necessary to improve, using self-assessment and inviting input from their peers. By using the elements of the Productive Pedagogies framework, the teachers were able to comprehensively and routinely review their lessons. Moreover, the reviews of the different lessons were used by the teachers to help them to improve the quality of their teaching in subsequent lessons.

4.4 Research Aim 3: Effectiveness of the Productive Pedagogies Framework as a Means of Reform

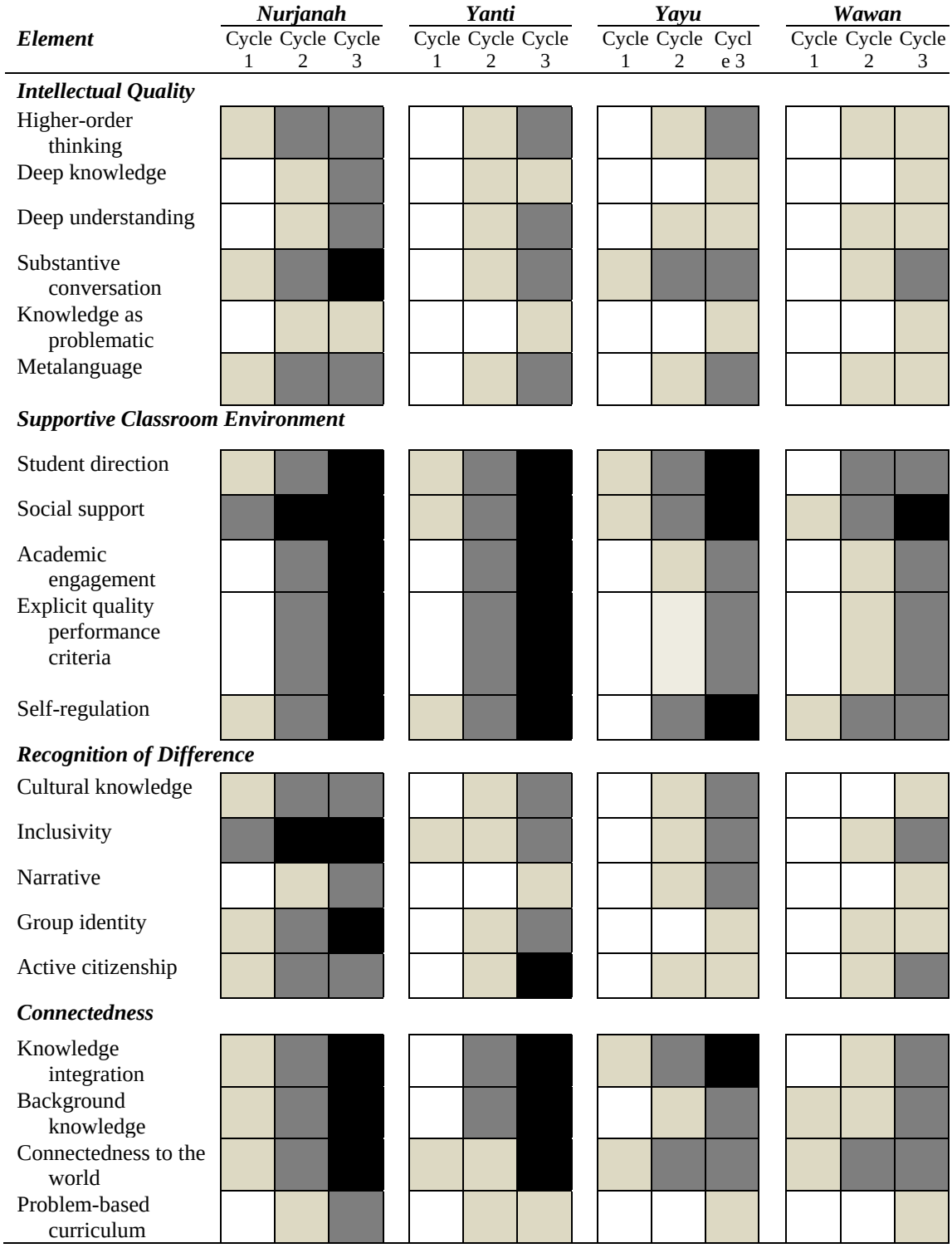
Whereas the previous sections discussed the challenges experienced by teachers as they implemented the Productive Pedagogies framework and the use of the framework as a means of reflection, this section focuses on the effectiveness of using the Productive Pedagogies framework as a means of changing what happens in the mathematics classroom. The success of the teachers, in terms of implementing the Productive Pedagogies framework, was quantified for each teacher and is depicted below in Figure 4.1. This figure indicates that the degree to which the three teachers were successful varied. For example, Nurjanah experienced the most success in implementing the elements, with many of the elements being implemented successfully on a regular basis. In contrast, Wawan showed the least improvement in the success of his attempts to incorporate the elements. Despite the varying degrees of success, it was heartening to note that, over the course of the three action research cycles, all four teachers made improvements.

Analyses of data collected through classroom observations, post-lesson reflections (teaching reflections) and interviews with teachers and students, over the course of the three action research, led to the emergence of three major themes that provide an indication of the effectiveness of using the Productive Pedagogies framework, these being: improved classroom interactions (Section 4.4.1); increased relevance to the real world (Section 4.4.2); and enhanced social justice in mathematics education (Section 4.4.3).

4.4.1 Improved Classroom Interactions

As discussed earlier, the teachers attempted to shift their teaching style from using a predominantly teacher-centred approach (entailing one-way communication) to one that involved a range of teaching strategies. This section reports the changes in their teaching style from before they used the Productive Pedagogies framework, to after they had implemented the Productive Pedagogies framework over the three action research cycles.

Prior to the introduction of the Productive Pedagogies framework, the teachers all based the delivery of the lessons on the curriculum content and used a lesson plan format that did not require them to consider deeply the role of teaching and learning. The pre-intervention observations indicated that all four teachers used expository teaching. Further, the interviews held before the introduction of the Productive Pedagogies framework, indicated that they felt that expository teaching was the most efficient in terms covering the content of the lessons and an appropriate method for any mathematics topic. Yanti mirrored the view the other teachers when she asserted, “In my opinion, expository is the best teaching method if we want teach many topics within a short period” [In-depth Interview].



Legend:

- The teacher attempted to use the elements, but was largely unsuccessful (2– 3)
- The teacher used the element, sometimes successful but not often (4 – 5)
- The teacher used the element and was reasonably successful (6– 7)
- The teacher used the element and was consistently successful (8 – 9)

Figure 4.1: Building Teachers' Capacity by the End of Each Cycle over the Three Action Research Cycles

After studying and implementing the Productive Pedagogies framework, the teachers agreed that the choice of teaching strategies was likely to determine the success of the teaching and learning process and, in turn, influence the quality of learning outcomes. To this end, Yayu stated: “A teaching strategy potentially influences the process of teaching and learning, and eventually determines the learning outcomes” [Focus-group interview]. Yanti, agreed, saying, “I am sure that choosing teaching strategies is important for students to get their highest achievement [Focus-group interview].

After studying the Productive Pedagogies framework, the teachers all attempted to incorporate elements of the Productive Pedagogies framework. This section describes the changes made by teachers as they implemented strategies in terms of student to teacher interactions (Section 4.4.1.1); and student to student interactions (Section 4.4.1.2).

4.4.1.1 Improving Student-Teacher Interactions

Classroom observations and focus-group interviews indicated that, over the course of the three action research cycles, teachers attempted to change their interactions with students by moving to a less dominant role in the classroom. In doing this, the teachers moved away from their teacher-centred role to one in which they helped students to refine their ideas and to facilitate their learning. For example, Yanti, in one of her lessons, used a whole class discussion to involve the students in establishing a definition for fractions, as described in the transcript below.

Teacher: *All of you have learned about fraction when you were in elementary school. Didn't you? Who do remember what fraction is?*

Desy: *I still remember, Mam.*

Teacher: *What is fraction?*

Desy: *A fraction is part of whole.*

Teacher: *That's a good idea, Desy.*

Teacher: *Wawan, do you have another definition of a fraction?*

Wawan: *A fraction is a part as distinct from the whole of anything*

Teacher: *That's great. Are there any other opinions, about what fraction is?*

Budi: *I want to add to Wawan's definition.*

Teacher: *Please Budi. What is your suggestion?*

Budi: *A fraction is a part as distinct from the whole of anything that consists of a top number and a bottom number*

Teacher: *Very good, Budi! Your description is more complete than Desy's and Wawan's.*

Teacher: *Nani, what are the top and the bottom number that Budi spoke of?*

Nani: *The top number, called the numerator, says how many we have. The bottom number, called as the denominator, says how many parts the whole is divided into.*

Teacher: *Wonderful, Neni! What do you think about Neni's description of a fraction?*

Students: *That's right, Mam.*

Teacher: *Are there any other comments? Don't hesitate, please raise your hand.*

Teacher: *If there are no other comments, please write five examples of a fraction and draw a picture of each that illustrates each fraction.*

The example illustrates how the communication between the students and their teacher changed from a more didactic interaction (that was common prior to the introduction of the Productive Pedagogies framework), to one in which the teacher encouraged the students to participate and to express their understanding of what a fraction was. During this classroom observation, the teacher appeared to be genuinely pleased with the responses of the students, praising their efforts. The teacher also showed patience as she facilitated the discussion to help the students to gradually refine their description of what a fraction was.

These interactions were in sharp contrast to how Yanti had previously taught students (using a transmission approach) and would appear to be attributed to change in her views about how students attain knowledge. To this end, Yanti asserted:

> Implementing Productive Pedagogies has encouraged me to develop a positive interaction with my students in order to make their learning more productive. To do this, I needed to shift away from my dominant role so that I could facilitate my students in developing their knowledge. I believed that, when the learning was productive, the students were able to understand the content of the lessons more easily. [Focus-group interview].

My classroom observations (illustrated in the example above) indicated that, over the course of the three action research cycles, the teachers tried hard to include all of the students in the whole-class discussions. Whereas, previously, classroom discussions had generally focused on a select few, once the teachers started to implement the Productive Pedagogies framework they invited more students to give their opinions, share their ideas or to make comments. One way that they did this was to encourage students who were not fluent in the Bahasa Indonesia, even though this was the official language, to use their mother tongue – Sundanese – to express or illustrate difficult-to-understand mathematical concepts or when they did not know the appropriate words in Bahasa Indonesia. They used words such ‘pasagi’ instead of ‘bujursangkar/persegi’ (square), ‘lonjong’ instead of ‘elips’ (ellipse), ‘dibantun’ instead of ‘dikurangi’ (subtraction), ‘kakalian’ instead of ‘perkalian’ (multiplication) and so on. By using Sundanese words the students were better able to explain or discuss the mathematical concepts and to become involved in learning activities. One of the students, Agung, said, “It is exciting that we are allowed to use Sundanese

words in our mathematics learning" [In-depth interview]. Another student, Didi, commented that, "Using Sundanese words to express ideas that I don't know in Indonesian helps me to understand the concept I am learning" [In-depth interview].

The teachers also changed in the way in which they responded to students' responses. Prior to the introduction of the Productive Pedagogies framework teachers were disparaging of incorrect responses. In some cases the teachers became angry or belittled students' responses or answers with responses such as "Your answer is wrong!" and "I need the correct answer!" After the introduction to the Productive Pedagogies framework, the teachers encouraged students to help to refine their peers' ideas with comments like, "Does anyone have another answer?" or "Do you agree with your friend's answer?" In this way, the teachers encouraged students to contribute to the discussion and to refine the ideas of others. In one class, taught by Yayu, which students were learning to solve equations, the teacher led the lesson as follows:

Teacher: *Suppose we have an equation 4y + 6 = y + 27. Do you remember what the equal sign represents?*

Ratih: *I know Mam, the equal sign represents a balance.*

Teacher: *Budi, what do you think about Ratih's answer?*

Budi: *I agree with her, the equal sign represents a balance.*

Teacher: *What does an equal sign say?*

Budi: *What's on the left side is exactly the same as what's on the right side.*

Teacher: *That's great, Budi. Are there any other comments?*

Dede: *That's correct, Mam. I agree with Budi's opinion.*

Teacher: *Can you apply what Budi said to determine the y of the equation (4y + 6 = y + 27)?*

Dede: *The first step is to gather all the y's together and to gather all the numbers together.*

Teacher: *Can you write your answer on the white board?*

Dede: *Yes, Mam. From 4y + 6 = y + 27 we can subtract y from each side.*

4y + 6 = y + 27

4y + 6 - y = y + 27- y

4y - y + 6 = y - y + 27

3y + 6 = 0 + 27

3y + 6 = 27

Teacher: *Do you know the second step?*

Dina: *We can subtract the number with a certain number from each side.*

3y + 6 - 6 = 27 - 6

3y + 0 = 21

Teacher: *Why do you subtract each side with 6?*

Dina: *That's in order for the y to be on the left side and the number to be on the right.*

3y = 21

3y : 3 = 21 : 3

y = 7

Teacher: *Ratih, what do you think about Dede's and Dina's steps?*

Ratih: *If we do anything to one side of the equation we have to do it to the other side.*

Teacher: *That's great Ratih. Does anyone have anything to add to Ratih's statement?*

The implementation of the Productive Pedagogies framework encouraged the teachers to limit their dominant role and to help the students to refine their ideas. Additionally, the teachers attempted to include all members of the class in all learning activities, invite all students to respond to questions and to comment on the ideas of others' responses, show appreciation to the responses of all members of the class and encourage students to help their peers to refine their ideas.

4.4.1.2 Improving Student to Students Interactions

Prior to the introduction of the Production Pedagogies framework, the teachers rarely encouraged the students to engage in dialogue or to share their ideas with each other. The teachers tended to control the activities, disciplining and regulating the students' movements with interactions such as 'Sit down and pay attention' or 'If you were not serious, I will punish you'. As a result, the interactions between students, during mathematics classes, were minimal.

It would be fair to say, that the improved student to student interactions, observed after the introduction of the Production Pedagogies framework, was influenced by the improved interactions between the teacher and the students. All of the teachers, in all of their interactions with the students, attempted to model the types of behaviours that they would expect from the interactions among their students.

To improve the interactions between students, during the actions research cycles, the teachers focused on elements included in the Productive Pedagogies framework that would support this, such as, *social support, academic engagement* and *inclusivity*. In doing so, the teachers were mindful that a positive interaction among students would be likely to create interactive dialogue, thereby enhancing the learning process.

As a starting point, the teachers encouraged mutual respect and support among the students in which the students with less skill or proficiency were treated in ways that would make their presence valued. For example, the teachers asked the students to applause when their peer(s) had a good idea or provided constructive suggestions.

This appeared to increase the students' willingness and confidence to make comments.

My initial classroom observations indicated that, in all of the classes there were only a few students who answered questions and, for the most part, these tended to be the same students. For example, during one lesson observed prior to the introduction of the Productive Pedagogies framework, Wawan asked "Who of you can give me examples of our daily life?" Only two students, Agung and Tita, raised their hands to answer the question. Agung said that fraction could be used when one wants to divide land into parts and Tita said, "We use fractions when we want to determine the time portions of our activities within a day". This low number of students who showed a willingness to respond was not uncommon in any of the classes observed prior to the use of the Productive Pedagogies framework in teaching. In contrast, by the end of the three action research cycles, more students responded the teachers' questions and this was the case for all four teachers.

One of the biggest problems with respect to improving the interactions during whole class and small group sessions was the students' reluctance to participate in discussions. When the teacher asked questions, even when encouraged to do so, the students were hesitant and, in most cases, only the high achieving students responded. The teachers used a number of strategies in attempts to improve the participation of the students. During discussions, teachers asked questions that differed in difficulty (to give students of differing abilities the opportunity to be involved), starting questioning. They also tried starting with easier questions and

then gradually increasing the difficulty of the question. The teachers asked lower ability students to respond to improve their confidence.

Another problem associated with the low involvement of students in whole class discussions was that there were, in all classes, a number of more dominant students who were, generally more able as well. In a bid to reduce the dominance of these students (and to give the other students an opportunity to get involved), the teachers also asked students to raise their hands (whereas traditionally the responses had been chorused). This gave the teacher the opportunity to select a range of students. Ali, one of the students said that, "I am happy when teacher asks me questions and I can answer the questions." [Focus-group interview]. Over the course of the three action research cycles, I noted that the teachers became more conscious of selecting a range of students.

By the end of the third action research cycle, more than half of the students, in each of the teachers' classes raised their hands when the teachers asked questions, compared to 10 percent of students who raised their hands prior to the introduction of the Productive Pedagogies framework. These attempts appeared to have a significant impact in improving the confidence of the students. One of Wawan's students, Anita, asserted: "I am more excited to attend mathematics class since our teacher changed her teaching style. My motivation increased and I am more confident to be involved in learning activities." [Focus-group interview]. Being able to see the steady progress that the Sundanese students were making through the particularised approaches and strategies that they had implemented further reinforced the teachers' appreciation of

the Productive Pedagogies framework and how its use empowered their students to engage more meaningfully in the learning of mathematics.

Another way that the teachers encouraged more positive student interactions was the use of cooperative learning groups in which each of the members selected one of three roles, these being, group leaders (responsible for coordinating the group activities), group secretaries (responsible for recording the ideas, comments and results of the group discussion) and group presenters (responsible for presenting the results of the group discussion to the class). Group work, such as this, was not used prior to the introduction of the Productive Pedagogies framework, and my observations indicated that, this made a difference to the interactions among students. Whereas, prior to the introduction of the Productive Pedagogies framework, there were few, if any, opportunities for students to interact with each other, the use of group work gave opportunities for the students to interact.

Initially, students who were more able were not only more outspoken but also more confident and tended to dominate group sessions. To give opportunities for other students to be involved, the teachers made a point of making sure that the more dominant students were not always group leaders. When listening to group interactions the teachers also reminded the students, who previously dominated classroom interactions, to give their peers opportunities to be involved in the learning activities. Further, during whole class activities, the teachers used a method of selecting students to answer questions, express their ideas and give comments, as discussed above.

Over the course of the three action research cycles the interactions among students gradually increased as students became more familiar with what they needed to do in these settings. For example, the group leaders gradually showed more responsibility and ability to coordinate the group activities, while the group secretaries became better able to write the ideas and comments made during the group activities.

Interviews with the teachers indicated that they valued creating positive relationships within the class to promote student learning. All of the teachers agreed that the interactions among students had the potential to enhance the quality of their students' learning. As Yayu remarked, "A positive relationship among the members of class has made the learning environment more conducive to attain the learning objectives" [In-depth interview]. Another teacher, Nurjanah, asserted: "The Productive Pedagogies has encouraged me to develop a positive relationship with my students in order to make them productive within their learning. I believed that when the learning is productive the students are more able to understand the content of the lessons." [Focus-group interview]

Another change made by the teachers was that they consciously refrained from commenting on the students discussions during group work. Rather than make comments or provide answers, the teacher encouraged the students to ask questions about the topic if they did not understand. For example, in one of Yanti's lessons, the students in one of the groups were observed to have difficulty in distinguishing the types of fractions and the operations that were being used. In this case, Yanti made a point of encouraging the students to ask questions of other students, who answered

them, rather than providing the answers to the problems. In this way, she was able to guide the students to find the answers amongst themselves.

After the introduction of the Productive Pedagogies framework, the four teachers all made attempts to improve the interactions between their students by providing group activities in which students selected a specific role, refraining from interrupting students' activities and valuing these positive relationships within the class. It would appear that these improvements in classroom interactions were related to the implementation of a range of elements, including, *academic engagement* (students are engaged and on-task during the lesson), *social support* (classroom is characterised by an atmosphere of mutual respect and support between students and teacher, and among students) and *inclusivity* (students from diverse background are actively engaged in learning). As a result, the observations indicated that the interactions among the members of the class improved with more interactive dialogues peers, rather than with the teacher.

4.4.2 Increased Relevance to the Real World

One of the biggest challenges that faced the teachers as they implemented the Productive Pedagogies framework was making mathematics relevant to students. The traditional approach used by mathematics teachers in Indonesia often focused on algorithms and procedures with limited emphasis on students understanding and the application of mathematics to their lives. Before the implementation of the Productive Pedagogies framework, Yayu stated that, "I teach all mathematics topics based on the order within the text book, starting with definitions and procedures,

examples related to the definitions and procedures, and ending with exercises. I show the applications of the concepts of the topics when they are contained within the text book. I wouldn't show the applications of the concepts when I didn't know them" [Sharing experiences in workshop discussion].

Even though teachers could see the value in making mathematics more relevant, initially, they were unsure about how to do so. For example, Wawan expressed that, "I understand that when students know the relevance of mathematics concepts they are more likely to be motivated to learn mathematics. However, showing the relevance of mathematics concepts is sometimes difficult. When I am unsure of how to go about it, I do not try to show students its relevance" [Focus-group interview]. Similaraly, Yanti said that, "I will show students the applications of the math concepts that I am teaching when I am sure of its application to their life but not if I don't know it. I feel that not all math concepts easy to be showed its applications" [Teaching reflection]. Although, for some concepts, teachers were still unsure about the applications of mathematics concepts to the students' lives, over the course of the three action research cycles, they gradually became more confident. This section reports how teachers made learning more relevant to the students by using students' prior knowledge (Section 4.4.2.1), connecting the content of the lesson to other topics that the students had studied (Section 4.4.2.2), connecting the lesson to the lives of students outside of school (Section 4.4.2.3).

4.4.2.1 Connecting to Students' Prior Knowledge

Although the prevailing view of the teachers, prior to the implementation of the Productive Pedagogies framework was akin to students as 'empty vessels', the

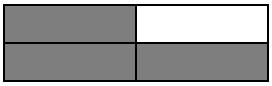
workshop, used to develop teachers' understanding of the framework, helped them to recognise the value of students' background knowledge. Yayu remarked that, "I never used to examine my students' background knowledge before I started a new lesson. After studying the Productive Pedagogies, I realised that it was an important consideration." [Teacher reflection].

Having agreed that students already had experiences that could be used to help to bridge their new knowledge, the teachers attempted to provide, in every lesson, opportunities for students to connect their prior knowledge with the topics that they were learning. Over the course of the three action research cycles, students' prior knowledge was incorporated more systematically into the lessons by the teachers. For example, observations held prior to the introduction of the Productive Pedagogies framework indicated that Yayu never involved students' prior knowledge before she commenced her teaching (see Table 4.2) but, after the first action research cycle, she began to understand that checking students' prior or background knowledge before beginning a new topic was important, as it provided students with a basis for the new concept. At the end of the second action research cycle, according to her, she became more aware that prior knowledge should be presented at the beginning of teaching new topics to support students' understanding of the new mathematical concepts. During this cycle, she found that if the prior knowledge required had not been mastered by the students, it was better not continue to teach but, rather, to make sure that the students understood the basic concepts before continuing. At the end of the third action research cycle, as reflected on Table 4.2, observations indicated that Yayu consistently incorporated students' prior knowledge into all of the lessons. The extract provided below, taken from one of Yayu's

Lessons that were taught in the last action research cycle, helps to illustrate her use of prior knowledge in her teaching.

The lesson is about the conversion of fractions. Yayu began the lesson by examining what the students had learned before.

Teacher:	*Have you ever learned fractions?*
Students (Chorus):	*Yes, we have.*
Teacher:	*Can anyone tell me what a fraction is – if you can still remember?*
Lina:	*I still remember. When an object is divided into a number of equal parts, then each part is called a fraction*
Teacher:	*Is that correct, Gani?*
Gani :	*Yes, I agree with Lina*
Teacher:	*Gani, can you please give me some examples of fractions?*
Gani:	*5/6 and 7/4*
Teacher:	*So, in the first example of a fraction given by Gani, what do the '5' and '6' represent?*
Nining:	*The 5 is the numerator which tells us how many many parts in the fraction and the 6 is the denominator which is how many equal parts in the whole object.*
Teacher:	*Well done Nining. Then, talking to the rest of the class she adds, How many type of fraction do you know?*
Bona:	*Three types*
Teacher:	*Good Bona, can you tell me what they are?*
Bona:	*Proper fraction, improper fraction and mixed fraction*
Teacher:	*Great. Well done. Can anyone tell me what a proper fraction is?*
Hani:	*Proper fractions are fractions whose numerators are less than the denominators.*
Teacher:	*Well done. Can you give me an example and draw it, Hani?*
Hani:	*Of course, Mam. Hani moves to the board. I choose 3/4 and this is the picture that represents 3/4.*



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Teacher looked to the rest of the class and asked:

	What do you think of Hani's diagram? Can anyone tell me more about it?
Rita:	*The total number of equal parts in Hani's diagram is four, and three parts are shaded. The shaded parts represent 3/4 in the fraction.*
Teacher:	*Can you tell me more, Evi?*
Evi:	*Because the numerator or the top number is less compared to the denominator or the bottom number, this type of fraction is called proper fraction.*
Teacher:	*That's great! Now let's move on to improper fractions. What is an improper fraction?*
Budi:	*Improper fractions are fractions with a numerator that is either equal to or greater than the denominator.*
Teacher:	*Who can give me some examples?*
Mimin:	*The fractions 8/7, 9/5 and 12/12 are all improper fractions. The top number or the numerator is greater than or equal the bottom number or the denominator.*
Teacher:	*What about 4 and 12?*
Dino:	*They are natural number*
Teacher:	*Are they fractions?*
Intan:	*No, they aren't fractions*
Budi:	*Yes, they are fractions, because 4 can be written as 4/1 and 12 can be written as 12/1*
Teacher:	*So what do you think about these two different answers.*

Students call out that they agree with Budi's answer.

Teacher:	*So, what is your conclusion, Budi?*
Budi:	*Every natural number is an improper fraction because every natural number can be written as a fraction in which 1 as its denominator*
Teacher:	*Good, let's continue. Who know what a mixed fraction is?*
Wanda:	*A mixed fraction is a combination of a whole number and a proper fraction is called a mixed fraction*
Teacher:	*Would anyone like to add to that?*
Bambang:	*A mixed fraction is a fraction which contains of two parts which are a natural number or a whole number and a proper fraction called a mixed fraction.*

Teacher: *Can you give me examples of mixed fractions and explain more about them Bambang*

Bambang: *$5^{1}/_{2}$, $9^{3}/_{4}$ and $21^{6}/_{9}$ are the examples of mixed fractions. So for $5\ ^{1}/_{2,\ The}$ 5 is the natural number part and the 1/2 is the proper fraction part, and 5 $^{1}/_{2}$ means 5 + $^{1}/_{2}$*

The teacher then went on to teach students about converting mixed fractions to improper fraction and the conversion of improper fractions into mixed fractions.

The extract provides an example of how Yayu sought to examine students' prior knowledge before going on to teach the next step of her lesson, something that had not been done prior to the introduction of the Productive Pedagogies framework. As described earlier, the use of students' prior knowledge was something that gradually became more prevalent at the start of lessons over the course of the three action research cycles.

4.4.2.2 Connecting to Other Topics Subjects

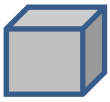
All four of the teachers had, prior to the introduction of the Productive Pedagogies framework, considered integrating the mathematics topic with other subjects or topics. In particular, Nurjanah stated that she frequently attempted to do so. In all cases, however, the teachers were unsure of how effective such integration would be in terms of attaining the teaching objectives. The introduction of the Productive Pedagogies framework appeared to convince the teachers of connecting mathematics to other topics as they felt that this would support the various concepts. Therefore, throughout the action research cycles, the teachers endeavoured to connect their lessons with other relevant mathematics topics, to help the students to understand that there were relationships between mathematics concepts. In doing this, the teachers were able to provide relevant illustrations and, in some cases, integrate subject areas outside of mathematics into the lessons (using the elements of *knowledge integration* and *connectedness to the world*). The enthusiasm to

incorporate these elements was captured by Nurjanah, who stated: "After considering the dimension of Connectedness, I am motivated to teach mathematics by integrating a range of subjects and providing mathematics applications connecting the concepts as the illustrations" [Focus-group interview].

The success of connecting the mathematics topics differed for the four teachers and my observations indicated that, whilst both Yayu and Wawan used this teaching strategy, they were not effective in making a difference to their students understanding of what they were learning. Yanti and Nurjanah, however, both were successful in connecting what they were teaching to mathematics topics that the students' had already learned. One example, provided below, shows how Yanti, in her lesson on calculating the surface area of cube, made explicit connections to a topic that had been taught earlier to help students in their learning.

Yanti began her lesson by showing the students a cube, made of paper and, using a conversational approach she asked the students to identify the properties of a cube (something that they had learned in primary school).

Teacher: *What is this?*

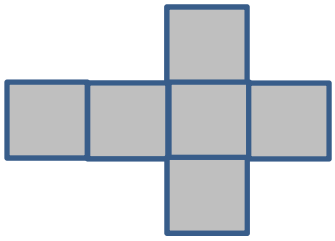


Anita: *A cube*
Teacher: *What shape are the sides of a cube?*
Dadang: *Squares*
Teacher : *How many squares?*
Cinta: *Six squares*
Teacher: *Are you sure? Can you show us the number of squares that make up the cube?*

(The teacher gives the cube to the student who showed each of the surfaces and counted them.)

Cinta: *One, two, three, four, five and six*

The teacher then pulled apart the paper cubes, removing the removing the squares that formed the six sides. She showed this to the students.



Teacher: *Look at the template and tell me how many side the cube has?*
Agus: *Six sides which are squares*

The teacher then asked the students to consider the formula for the area of a square, a formula that the students' would have learned in primary school.

Teacher: *Do you still remember the formula of the area of a square?*
Agus: *Yes, I remember, a x a = a^2*
Teacher: *Good. So we know that the surface area of one square is a x a = a^2. We know that there are six squares in a cube. Who can tell me how we will work out what the total surface area will be.*
Dani: *The surface area will be equal to = $a^2 + a^2 + a^2 + a^2 + a^2 + a^2$*

By connecting their learning to a previous topic in mathematics, in this case the area of a square, the students were better able to grasp the more complex topics such as the one described above.

4.4.2.3 Connecting to the World

Over the course of the three action research cycles, the teachers also started to connect mathematics to the students' world. Although in some instances (as

discussed previously in Section 4.2) the examples that teachers used were not relevant to the topic, the teachers' choices also improved over the three action research cycles (as described in Table 4.2). For example, in her lesson on geometric shapes, Nurjanah decided that she would use a farming theme. She selected this because, being in a rural area, many of the students were from a farming background and all of them were familiar with farms. Therefore, she selected pictures that illustrated geometric shapes on a farm. Interestingly, the pictures that Nurjanah selected were not very typical of Indonesian farms and included buildings that not necessarily familiar to students. Also of interest is that the shapes represented in the picture were not geometrically correct. Both of these points were bought up during the reflection session and, based on this session, Nurjanah indicated that these were things that she would consider in the future.

Nurjanah began the activity by discussing the picture with the students' in general, asking them to identify objects that they might commonly find on a farm. She then went on to ask students to identify objects that they might find on their own or on neighbours' farms. They identified animals, machinery and buildings that they recognised. The teacher then went on to ask the students to work together in groups to identify shapes of objects that they would find on their parents or neighbours farms. She then asked the students to work in groups to discuss, list and draw the objects and their shapes. In doing this, despite the lack of relevance that the picture had to typical farms in Indonesia, Nurjannah was still able to connect what students were doing in mathematics to their world.

[redacted]

[redacted]

Another way that teachers' tried to make the lessons more relevant was to incorporate students' ideas into their lessons. For example, in one lesson Yanti introduced a new topic by inviting the students think of issues related to their daily life. The students put forward a range of suggestions, including the rise in prices, juvenile delinquency, traffic jams and the need to be healthy. She then asked the students to consider how the issues might be relevant to the topic that they were learning (changing percentages into fractions). Using these issues the students helped to develop problems that involved changing percentages to proper fraction and improper fractions. Below is a short extract of the lesson that Yanti taught using the students' ideas.

Teacher:	*Let us discuss one of the issues that you have suggested. Let's start with 'traffic jam'. What are usually trapped in during a traffic jam?*
Students (Chorus):	*Vehicles*

Teacher:	*What vehicles do you see in traffic jam, Ani?*
Ani:	*Cars, trucks, motorcycles.*
Teacher:	*That's good, can anyone suggest anything else?*
Dadang:	*Bicycles and pedicabs.*
(Calls out)	
Teacher:	*Those are both good ideas, Dadang.*
Teacher:	*Now, with your group, imagine that you were trapped in a traffic jam. Please work together to make up a list of the types of vehicles and the percentages of each type that are in that location. Write your ideas in your note book. Don't forget, this is not a real traffic jam, so your answers will not necessarily be the same.*

The students followed the teacher's request and, in groups, wrote an imaginary list of vehicles that could be in the traffic jam. They also made up a percentage for each.

Teacher:	*Now that everyone has written the percentages of each type of vehicle, you will now change the percentages into proper fractions.*

The students were worked together with members of their groups, to change the percentages to fractions. When they had finished, the teacher asked,

Teacher:	*Can your percentages be changed into improper fractions?*
Dina:	*No, I think that's impossible*
Teacher:	*Why not, Dina?*
Dina:	*Because the number of all vehicles is more than each kind of the vehicle, so the denominator must be bigger than the numerator.*
Teacher:	*That's great, Dina. Does anyone want to comment on this?*
Students:	*That's right, Ma'am*
(Chorused together)	
Teacher:	*Let's give a round of applause for Dina!*

Observations indicated that teachers gradually provided more opportunities for their students to negotiate the learning setting and the learning activities that would be used. As such, teachers invited the students to indicate whether they would prefer to work as a whole class or in groups or invited students to suggest ideas for learning

activities. Initially the students found this strange, but they gradually warmed to the idea and enjoyed being a part of these decisions.

4.4.3 Enhancing Social Justice in Mathematics Education

The Productive Pedagogies framework was designed to explicitly attend to both intellectual and social justice outcomes. Social justice in mathematics teaching and learning requires teachers to create learning environments that enable all students, regardless of background or ability to participate in the mathematics teaching and learning process and, at the same time, decrease social in-justice in practice. Important to the present study, therefore, was the examination of whether the introduction and implementation of the Productive Pedagogies framework did indeed bring about improvements in terms of social justice in the mathematics classrooms of the four teachers.

My observations, held prior to the implementation of the Productive Pedagogies framework, indicated that, the extent to which social justice was taking place in the mathematics classrooms of the four teachers was lacking. By and large, all four of the teachers tended to treat the students in ways that were inequitable. That is, the teachers focused their attention on a small number of students. For these few students, the teachers were more likely to ask them questions, make sure that they understood the work and direct their attention to them during the lesson. These students all were more vocal than their peers and demonstrated an aptitude for mathematics.

The remainder of the students were, on the whole, ignored. My observations indicated that the teachers did not always provide challenging or engaging opportunities for their students. Therefore, I was not surprised that, during mathematics lessons, the majority of the students appeared not to concentrate or were disengaged from the teaching and learning process. These students were observed to be involved in a range of off-task behaviours such as drawing in their books, talking to others or staring out of the window. (These observations and other findings related to student engagement are elaborated on in Section 4.4.)

Once teacher teachers started to become familiar with the Productive Pedagogies framework, they began to recognise their actions in terms of social justice. Yayu was one of the first to acknowledge this, when she announced, during a focus group interview, “I have been treating my student unfairly by focusing only on certain students. I have neglected the needs of the other students when I should have been supporting them and helping them to understand the lesson”.

The teachers began to realise that they had not encouraged a large number oftheir students as mathematics learners or provided experiences that would foster an effective educational process. Wawan said, “My teaching of mathematics has been restricted to referring to the curriculum and my goal was to finish the different topics within the curriculum as quickly as possible” [Teaching reflection]. Yanti went further to say, “I feel guilty. In the past I have frequently served only certain students and overlooked the other students. The Productive Pedagogies framework has reminded me that teachers should treat all students fairly regardless of their background” [Teaching reflection]. Nurjanah also stated “Many of my students have

not received their rights in rights as mathematics learners with sufficient opportunities to explore mathematics comprehensively.

After the introduction of the framework, the teachers agreed that mathematics teachers should encourage all students regardless of their background or perceived academic ability, to be involved in learning activities and to motivate them to contribute to the learning process. To this end, Nurjanah asserted that, "After studying the Productive Pedagogies, I decided to always make sure that my teaching was not focused on certain students but, rather, on all students, whoever they were" [Focus-group interview].

Building on the previous sections, which provide many examples of enhanced social justice, this section examines how social justice in the mathematics classrooms of these teachers was enhanced after the implementation of the Productive Pedagogies Framework. The section starts with a short narrative, describing one lesson, taught by Wawan, which was designed using the elements of the framework. After the narrative, a commentary based on the story is provided to examine how the individual elements had served to enhance social justice in the mathematics classrooms.

> *When I had first observed classes by Wawan (prior to the introduction of the Productive Pedagogies framework), the students were engaged largely in lower-order thinking. Wawan stood at the front of the class orating factual information. There was an order to the delivery of the lessons that involved starting with giving the student a definition or rule that needed to be learned then going through the procedures that needed to be followed. He then worked some examples on the white board. I noted that, when he*

asked questions, it was always the same students who answered, generally, by calling out. Whenever he looked to the class, he addressed his lecture to these same students. The only breaks from the lecturing were when students recited what the teacher had told them, copied notes from the board or carried out the worksheet activity that they had been set.

After the introduction of the Productive Pedagogies framework, I observed a lesson, taught again by Wawan, which utilised a collaborative approach. This lesson was a far cry to the lessons I had observed prior to the implementation of the Productive Pedagogies framework. Not only did the lesson involve higher order thinking but it also showed how social justice in the classroom had been enhanced by including the elements of the framework.

Wawan was teaching the use of operations in fractions and started by asking the students to move into groups that had been predetermined and based on friendships. Using a list that he had written on the white board, he asked the students, as a means of revision, to discuss the definitions of what a fraction, nominator and denominator were. Once the students had done this, and the groups had reported back to the class, Wawan wrote some examples of fractions on the whiteboard. He then went on to ask the student to write down as many variations of fractions as they could think of in their group work sheet.

The students were then asked to work together to classify the different fractions based on information provided in the nominator and denominator. The groups worked together and classified the fractions based on whether the numerators were less than the denominators, the numerator were either equal to or greater than the denominator, or the fraction combined a proper fraction and a whole number. The students were then asked to name the different types of fractions (proper fraction, improper fraction and mixed fraction) and, in their groups, to make up a definition using their own words.

Once the revision was complete, Wawan went on to show the students how to evenly divide a one-meter length of plastic rope shorter, equal lengths by folding it. He then gave a length of rope to each of the groups and asked the students to work out how they could divide the rope into different fractions (such as quarters, thirds and halves). There was an immediate buzz of noise as the students voiced their opinion on how this should be done.

Once the groups were satisfied with how they would evenly divide the ropes into the different fractions, Wawan gave a length of rope to each of the students. He then showed the students a list of problems that were on the whiteboard. The problems were varied but one of them asked,'Suppose you have a three-meter length of rope. If you were to divide the rope into four shorter pieces of the same length, how long will each piece of rope be?' This was followed by 'In order for one of the pieces of rope to be one-meter in length, how many more metre would you need?' Another problem read, 'At a scout camp, a team with eight members want to make a rope fence to show the boundary of the team's tents. Each member has a three-meter length of rope. The team members all agreed to contribute a quarter of a metre of rope to make the boundary. How will they determine the length of rope that will they contribute? After they combined the pieces of rope, how many meters long will the fence be?

He instructed the students to work together in their groups, using their rope to help them, to solve the problems. As they worked together, I observed the teacher walking around the classroom to look at what they were doing and how they were progressing with the learning activities. I noted that he approached and spoke to groups of students that appeared to be struggling or needed his assistance.

When the activity first commenced, almost all of groups faced problems. For example, one group was confused about how to convert a mixed fraction into an improper fraction. I noted that the teacher did not give the answer but, rather, he used questions to help the students to explore the

ideas. In this way, students were encouraged to find the formula themselves. He then encouraged the students to use the formula to solve the problem.

It was clear during the activity that the students were engaged and, in many cases, excited. There was much discussion and debating amongst the group members, with different members vying for their approach to be adopted. In some cases, I noted that the students' had to explain why they wanted to use a particular approach.

In one of the groups, I noted that there was a particularly vocal student. The teacher also noted this and, walking to the group, encouraged the other members to have a say. Although seemingly reluctant, some of the quieter students made comment and came up with ideas.

At the end of the session, the groups were asked to present both their solution and the methods that they had used to arrive at the solution. I noted that some groups used different approaches to get the solution of the problems to other groups. For example, one of the problems was required the students to work out two thirds add one half, take away one quarter. Some groups added two thirds and one half, first, then subtracted one quarter from the result. Another group subtracted one quarter from one half, then subtracted two thirds from the result. After all of the groups had presented, the teacher asked the students' comments on the presentation. The students were genuinely 'surprised' when they compared how they had solved the problem, to find that the final answers were the same – even though they had used different approaches to get the answers.

The lesson, described above, shows how, implementing the elements of the Productive Pedagogies framework had helped Wawan to create a classroom that was socially more just. It is important to note that, although the story is based on one teacher, all four of the teachers made similar changes. Wawan's story was selected

because he was the teacher who (based on the finding reported in Figure 4.1 and 4.2) made the least changes in terms of capacity. Despite this, the changes in his classroom, in terms of social justice, were still remarkable.

In this story, not only were all of the students engaged in a rich learning process that provided scope for deep mathematics learning but it also engaged all of the students by making the learning relevant. At the beginning of the lesson, Wawan asked the student to define various terms related to fractions. Rather than providing a definition (as he would have done prior to the introduction of the Productive Pedagogies framework), he encouraged the student, in their groups to come up with a shared meaning. In this way, Wawan had drawn on both the *inclusivity* and *group identity* elements of the framework. By discussing and deciding upon the best definitions, the students were not only drawing on and using their prior knowledge but, in some instances, were constructing new knowledge (drawing on the element of *higher order thinking*).

The intellectual quality dimension requires that teachers provide challenging activities that foster deep mathematical learning. The activity, described in the story, provided a range of challenges for the students and required them to consider, as a group, how they would solve the problems. The challenges provided in the lesson (to solve the problems) involved students working together and, as such, this aspect of the lesson drew on the element of *academic engagement*. Further, by discussing, negotiating and deciding on solutions to the various challenges, the students were involved in the *deep understanding* element.

The story depicts students discussing with each other, how they should solve the problem. As such, there was much *substantive conversation* generated during the activity as the students' explained and justified their methods that they should use. In this way, the students were engaged in a learning activity that fostered deep mathematical learning. Importantly, the activity, with its various challenges, ensured that all of the students, rather than a select few, were engaged in the mathematics lesson, drawing on the elements of *access* and *inclusivity*.

The story describes the student discussing how to convert a mixed fraction into an improper fraction. The teacher did not tell them how this was done but, rather, asked questions that guided the students. In this way, the teacher was drawing on the element of *knowledge as problematic*. The discussions that ensued between the students as they tried to resolve how they would change the fractions was evidence of *substantive conversation* and *academic engagement*. The fact that all of the students were involved in this discussion was evidence of *access and participation* (an important social justice element) in action. Further, the groups exploration of solving the problems that the teacher had set showed equity as all of the students were involved and considered.

The teachers agreed that making mathematics accessible and relevant was important in terms of social justice in the classroom. The story portrays a lesson in which the teacher, Wawan, made the lesson on fractions both relevant and accessible to the students by using examples (such as the scouting problem) that were a concrete means of calculating the problem, thereby increasing the access to mathematics and drawing on many elements of the Connectedness dimension.

One of the goals of mathematics education is to encourage all students to understand mathematics through connecting mathematical ideas to other concepts within mathematics, to other disciplines and to everyday life. Once mathematical ideas have been connected to other topics, other subjects and real-world phenomena, students begin to view and experience mathematics as an integrated, relevant and meaningful entity. The story depicts how students work in groups to solve problems that are relevant and then share both their answers and how they solved the problem. In this way, students were able to see that, in mathematics, there was more than one way to solve problems.

This story, although of one classroom, was representative in terms of the depicting the improvement in social justice across all of the teachers' mathematics classrooms. In this classroom, all of the students had an opportunity to be involved in the learning process and were able to contribute to the activity and to help to resolve the problems. This example, coupled with examples in Section 4.4.2, supported the notion that the implementation of the Productive Pedagogies framework improved the level of social justice within the mathematics classes of these four teachers.

4.5 Research Aim 4: Increasing Student Engagement

The last research aim was to investigate the impact of implementing the Productive Pedagogies framework on student engagement. This section reports whether student engagement, as indicated by the students' behaviour, improved after the introduction of the Productive Pedagogies framework. Observable behaviours, indicative of student engagement (or lack thereof), were used to determine whether the level of student engagement changed over time. Table 4.3 provides, for each behaviour, the average number of occurrences in a lesson for each action research cycle. The behaviours were separated according to whether they were considered to be negative behaviours (such as disruptive behaviour) or positive behaviours (such as concentrating). The results, reported in Table 4.2, indicated that, prior to the introduction of the Productive Pedagogies framework there were a large number of distracted (14 incidences), off task (12 incidences) and disruptive (15 incidences) behaviours.

Also reported in Table 4.2 are the positive behaviours that were observed prior to the introduction of the Productive Pedagogies framework, such as concentrating or being on task. The number of incidences, as an average for the eight classroom observations, totalled 18, and was less than the number of observations of behaviours indicating a negative demeanour.

Table 4.2 Student Engagement based on Incidences Reported in Field Notes

Behaviour	Frequency – average per lesson			
	Prior to *	Cycle 1**	Cycle 2**	Cycle 3**
Negative Behaviour				
Distracted (e.g. looking out of the window)	14	24	15	2
Off-task (e.g. drawing, doodling or playing games)	12	10	6	1
Disruptive (e.g. misbehaving, talking while teacher was teaching)	15	14	6	2
Total Observations indicating Negative Demeanour	*41*	*48*	*27*	*5*
Positive Behaviour				
Concentrating (e.g. focusing on the learning activities)	5	13	25	30
On-task (e.g. carrying out the teacher's requests)	7	11	30	28
Positive response to teaching (e.g. happy faces, smiling)	6	15	28	31
Total Observations Indicating Positive Demeanour	*18*	*39*	*83*	*144*

* prior to implementing the Productive Pedagogies framework there were 16 classroom observations
** during the implementation of the Productive Pedagogies framework there were a total of 101 classroom observations (*34 in Cycle 1, 35 in Cycle2 and 32in Cycle 3*)
(Incidences reported during observations – field notes)

Interestingly, for the negative behaviours there was little change in the first action research cycle (see Table 4.3). In fact, for one of the behaviours (distracted) the number of occasions increased. It is possible that this increase was the result of the teachers' inexperience with the use of the elements of the Productive Pedagogies framework. For the second and third cycle, however, there was a large decrease in the number of negative behaviours that were observed with an average of five observed negative behaviours in each lesson being observed in the third research cycle. This was in stark contrast to the 41 incidences of negative behaviours recorded prior to the implementation of the Productive Pedagogies framework.

Conversely, the average number of positive behaviours per lesson increased over the three action research cycles (see Table 4.2). Prior to the introduction of the Productive Pedagogies framework the average number of positive behaviours observed in each lesson was 18. In contrast, there was an average, per lesson, of 144 incidents of positive behaviour in the third research action cycle. These figures indicated that the students, over the last action research cycle were, generally, more enthusiastic during mathematics lessons. For example, they became more involved by raising their hands, responding to teachers' questions and, overall, had a happier disposition.

Student interviews were used to help to determine whether student engagement changed after the introduction of the Productive Pedagogies framework. For each stage of the research, Table 4.3 reports the number of comments made by students. Because the number of interviews held for each stage was different, the table reports both the number of comments and the percentage that this number represents, to allow comparisons.

Interviews carried out prior to the implementation of the Productive Pedagogies framework reflected the observation data, with the number of negative comments about mathematics (such as being bored or disliking mathematics) outweighing the number of positive comments (e.g. they enjoyed learning mathematics or they liked mathematics classes). Of the 14 students who were interviewed prior to the introduction of Productive Pedagogies framework, many expressed that they did not like mathematics, albeit for a range of reasons. For example, Anita, one of the students, said, "I am not interested in learning mathematics because I don't

understand what I learn. I have to attend the class as it is compulsary" [In-depth interview]. Similarly, Bambang, another student, asserted that, "Mathematics is one of the most difficult subjects and I don't like it; but unfortunately it is compulsory for all students" [In-depth interview].

Table 4.3 Summary of Interview Comments Related to Student Engagement

Comments	Frequency (Average per lesson)			
	Prior to (n = 14)	**Cycle 1** (n = 54)	**Cycle 2** (n = 54)	**Cycle 3** (n = 54)
Bored with learning mathematics	8 (57%)	35 (65%)	22 (41%)	0
Difficult to understand mathematics	9 (64%)	42 (77%)	19 (35%)	2 (3.7%)
Dislike mathematics	6 (43%)	19 (35%)	9 (17%)	1 (1.9%)
Fear of mathematics	5 (36%)	17 (31%)	8 (15%)	0
Uncomfortable about attending mathematics lessons	8 (57%)	28 (52%)	10 (19%)	1 (1.9%)
Total Number of Negative Comments	*36*	*141*	*68*	*4*
Enthusiastic about attending mathematics classes	5 (35%)	10 (19%)	23 (43%)	42 (78%)
Enjoy learning mathematics	2 (14%)	8 (15%)	28 (52%)	40 (74%)
Not scared of mathematics	4 (28%)	11 (20%)	30 (56%)	45 (83%)
Easy to understand mathematics	4 (28%)	9 (17%)	27 (50%)	34 (63%)
Like mathematics	3 (21%)	8 (15%)	30 (56%)	45 (83%)
Total Number of Positive Comments	*18*	*46*	*138*	*206*

- prior to implementing the Productive Pedagogies framework, 14 interviews were conducted
- during implementing the Productive Pedagogies framework , involved 12 focus groups and 9 in-depth interviews - (involving a total of 54 students)

Of the students who were interviewed before the implementation of mathematics, all but four of them of them suggested that the lessons were not interesting and, whilst the students did not explicitly state whether they liked mathematics or not, their comments suggested that mathematics was not a subject that they enjoyed. For example, one of the students, Dina, said that, "It is difficult for me to understand

mathematics lessons because I just copy what the teacher writes on the board and do what she asks us to do." [In-depth interview].

Initial interviews also indicated that, students found that the lessons to be difficult. For example Kiki remarked, "When I am attending mathematics lessons I feel that I am under pressure, and it is difficult to concentrate on what I am learning." [In-depth interview]. Another student, Neni, said, "I don't enjoy learning mathematics because the lessons are difficult to understand" [In-depth Interview]. Similarly, Bina stated, "I know that mathematics important, but I don't like learning mathematics because I can't understand the concepts." [In-depth interview].

The interviews with the students', held prior to the introduction of the Productive Pedagogies framework, indicated that most of the students (n=8 out of 14) found their mathematics lessons to be boring. Dedi one of the students said that, "Mathematics lessons are boring and I always want the teacher to end the lesson quickly" [In-depth interview]. In some cases, students indicated a fear of mathematics lessons. For example, Budi said that, "I am quite scared of attending mathematics classes because our teacher is fierce." [In-depth interview]. Similarly, Ina remarked, "Our mathematics teacher isn't friendly. It is one of the reasons I fear mathematics." [Focus-group interview].

Over the course of the three action research cycles, students became more likely to make positive comments about their mathematics classes and less likely to make negative comments (see Table 4.3). When compared with mathematics classes held prior to the introduction of the Productive Pedagogies framework, the number of

negative comments increased from 86 to 141, during the first action research cycle (reflecting the trends in the observation data) before dropping off dramatically in the second and third action research cycles. In the third action research cycle only four negative comments (in 54 interviews) were made.

Whilst the number of negative comments decreased, the number of positive comments increased over the course of the three action research cycles. By the third research cycle, students were more likely to express their enthusiasm to attend mathematics lessons, their enjoyment of mathematics, their reduced fear of mathematics and increased understanding of mathematics concepts. Interviews with the students indicated that they generally appreciated the change in the way that the teacher interacted with them. For example, Andi said, “For me learning mathematics used to be a nightmare. Now, I am feeling excited to attend mathematics class” [In-depth interview]. Mita said that, “I don’t know why our mathematics class is more interesting than before. I think this is because our teacher has changed the way that she teaches us.” [Focus-group interview]. Similarly, Dadang, remarked that, “I am now more at ease when I attend mathematics classes because to the changed teaching style of our teacher” [Focus-group interview].

It would appear that students were less likely to be afraid of making mistakes after the introduction of the Productive Pedagogies framework. To this end, Deny said, “I previously didn’t like mathematics and I was always afraid to attend mathematics classes because our teacher was often upset when we answered her questions incorrectly.” [Focus-group interview]. Similarly, Dudi stated, “Since our teacher no longer gets angry with us when we make mistakes and is friendlier and more patient

when she is teaching us, I am more confident in my mathematics class". [In-depth interview].

It would appear that the teachers' encouragement of the weaker students to share their ideas with their peers also helped to improve student engagement. At the outset, it was not easy for the average and lower ability students, as they lacked confidence. However, over the course of the three action research cycles these students gradually became more accustomed to speaking out and were positive about this change. Ami, one of the average ability students, said, "I am pleased when my opinion is accepted by my peers. It makes me more excited to become involved in other activities." [Focus-group interview].

In the third action research cycle, observations indicated that there was a general sense of enjoyment during the lessons that was not present previously. Although difficult to quantify, the students' appeared happier, both about attending mathematics classes and during the various activities provided by the teachers. The students also noticed this overall change, for example, Tuti, said, "Over the last few weeks our maths class has become more exciting, which makes me want to learn mathematics" [In-depth interview]. Another student, Bambang remarked, "I now enjoy learning mathematics and better understand what I am learning." [Focus-group interview].

In a number of my observations, the students enjoyed what they were doing so much that they lost track of the time. For example, in one lesson, taught by Yayu, the students were so engrossed that, when the lesson ended, they wanted to continue to

work. Some of the students asked the teacher to promise them that they could continue their un-finished activities in their next mathematics class.

The comments made by students indicated that, with few exceptions, they enjoyed the mathematics lessons more since the implementation of the Productive Pedagogies framework. To this end, Bina stated, “I now enjoy mathematics class because the learning activities motivate us to learn mathematics with joy” [In-depth interview]. Bambang agreed, saying, “I hope our teacher keeps the atmosphere of our mathematics learning like this. It really makes me excited to learn mathematics” [Focus-group interview]. Dadang, commented, “The way our teacher teaches us has changed; we are now involved in the activities she offers” [Focus-group interview]. Whilst Neni, asserted, “Because learning mathematics is now more challenging, everyone is more encouraged to engage in the mathematics class” [Focus-group interview].

The results indicated that, since the implementation of the Productive Pedagogies framework the teachers provided opportunities for students to select the learning activities and academic challenges. It would appear that this also improved students’ engagement. One of the students, Nani, said, “Allowing us to select our learning activities is exciting. By doing this, we can choose learning activities that we are interested in, which means mathematics lessons more exciting” [Focus-group interview]. Another student, Deny, asserted, “I am impressed with our mathematics class because we are involved in all learning activities, including selecting the activities. I like learning mathematics more now” [In-depth interview].

Although teachers succeeded in enhancing students' engagement in learning mathematics, it should be noted that there was still a degree of anxiety shown by some of the students who were struggling. One of the students, Tuti, said, "I am discouraged and unhappy when I cannot follow the teacher's instructions" [In-depth interview]. Similarly Neni, asserted, "I don't know why I feel jealous of others who can answer mathematics questions easily, while I have to work hard to do that" [In-depth interview]. Even though only a handful of students showed such anxiety, the teachers worked hard to ensure that these students were not neglected. In some cases the teachers gave these students additional assistance – something that they had not done previously.

Overall, however, the data indicated that, through the implementation of the Productive Pedagogies framework, students' engagement in the teaching and learning process improved, as indicated by the students' behaviour. It was evident during classroom observations as well as focus-group and in-depth interviews that the students felt that the teachers' new approach, since they had implemented the Productive Pedagogies framework, had impacted favourably on their attitudes towards and engagement in mathematics lessons.

4.6 Chapter Summary

This chapter reported the results of analysis used to address the four research aims. Data gathered using multiple research methods, including classroom observations, interviews with teachers and students and reflective journals (kept by the teachers and the researcher) were analysed.

Section 4.2 examined the challenges experienced as the teachers implemented the productive pedagogies framework. Teachers were, initially, resistant to change, feeling sceptical of the Productive Pedagogies framework and its applicability to the Indonesian context. Further, when they started to implement the changes into their classrooms, they were confronted with obstacles, such as student behaviour issues, that they had not experienced when using the expository method of teaching.

A further challenge was the lack of experience related to the implementation of the methods in the new paradigm. These teachers had never experienced these teaching methods, nor had they seen them in action. It was difficult, therefore, for teachers to envisage what the individual elements would look like. Another challenge that teachers' experienced was related to the amount of time required to implement the elements of the Productive Pedagogies framework. Although the teachers became increasingly aware of the benefits of the new teaching style, the time constraints placed upon them from a content-heavy curriculum meant that it was difficult to find the time needed to implement the elements effectively. Further, teachers' lack of experience in using the elements of the Productive Pedagogies framework, and the time constraints placed upon them, led the teachers, on some occasions, to make incorrect decisions.

Section 4.3 reports the analysis of the data related to the use of the Productive Pedagogies Framework as a tool for reflection. The teachers used the framework, in the first instance, to help them to develop lesson plans. After the lessons had been taught, teachers then used the framework as a means of comprehensively reflecting and evaluating their lesson in terms of whether the lesson objectives had been

achieved, the students' performance (in light of the lesson objectives) and the process of teaching and learning.

Section 4.4 reports the analysis of the data with respect to the effectiveness of using the Productive Pedagogies framework to improve classroom interactions, make mathematics more relevant to students and to enhance social justice in the classrooms. This section reports the increased interactions between students and between the teacher and students during mathematics lessons. Three main changes were identified as being the main cause of these changes in interaction, these being, a move from a dominant, teacher-centred role to one in which they facilitated the students' learning, the conscious inclusion of all students in the lesson and the interactions between class members and changing the way that they responded to students responses (so that it was more positive even when the response was incorrect).

The implementation of the Productive Pedagogies framework also led to mathematics teaching and learning that was more relevant to the lives of the students. The relevance of mathematics was improved through teachers' use of prior knowledge, connecting the mathematics learning to other subjects and to other mathematics topics that had been taught and by making activities relevant to the students' lives outside of school.

Social justice in mathematics was enhanced in the classes of all of the teachers. Teachers' became increasingly aware of the importance of providing all students with the opportunity to be engaged in the learning and teaching process through

providing meaningful and relevant activities that were intellectually demanding. The degree to which social justice was provided was increased through a number of means, and was evidenced in the increased engagement of students in the activities.

Section 4.5 reports the results of analysis conducted to examine whether the introduction of the Productive Pedagogies framework improved student engagement in mathematics classes. Over the three action research cycles, students' negative behaviours (such as being off-task) decreased and their positive behaviours, indicating engagement, increased. Further, interviews with students indicated that, over the course of the three action research cycles, they were more enthusiastic about attending mathematics classes and enjoyed the classes more.

Chapter 5
DISCUSSION AND CONCLUSION

5.1 Introduction

The research described in this thesis sought to investigate, on a small scale, the effectiveness of using the Productive Pedagogies framework as a means of reform in mathematics education in Indonesia. More specifically, the research investigated the challenges that confronted the teachers as they implemented the Productive Pedagogies framework, the use of reflection as an integral component of change, the effectiveness of the Productive Pedagogies framework in terms of improved interactions, connectedness and social justice in mathematics classrooms, and the impact of implementing the Productive Pedagogies framework on students' engagement in mathematics classes.

A five-day workshop was conducted to introduce the Productive Pedagogies framework to the four teacher-participants (from two schools) all of whom taught Year 7 mathematics. The implementation of the Productive Pedagogies in mathematics teaching was carried out over three action research cycles, each of which lasted approximately one month. Data were gathered using different kinds of qualitative methods, including, classroom observations, focus-group interviews, in-depth interviews and teachers' written reflections based on their teaching experiences.

This chapter concludes the thesis by summarising and discussing the major findings of the study (Section 5.2), explaining the limitations of the study (Section 5.3) and outlining the implications of the application of the Productive Pedagogies for both teachers and students in the framework of reforming mathematics education (Section 5.4). The chapter goes on to describe the significance of the research (Section 5.5), present the overall conclusions (Section 5.6) and provide recommendations to stakeholders and for future research (Section 5.7). Finally the chapter ends with a concluding remark (Section 5.8).

5.2 Summary of Major Findings

The following sections summarise and discuss the major findings and are organised around the four research aims.

5.2.1 Challenges Related to Implementing the Productive Pedagogies Framework

The first aim was to investigate the challenges that confronted the teachers as they implemented the Productive Pedagogies framework. Once the teachers had studied the Productive Pedagogies framework, over the course of a five-day workshop, they attempted to implement the framework and its elements to improve the quality of their teaching. During the implementation of the Productive Pedagogies framework the teachers experienced varying levels of success. Even though the success with which the teachers incorporated the different elements within the Productive Pedagogies framework gradually increased, at the end of the three action research

cycles there were still some elements that were not frequently implemented and the levels of success, experienced during their teaching, still differed. There was a range of reasons for this, including, the reluctance of teachers to change their teaching style, the teachers' lack of understanding of the elements, lack of experience in planning and implementing the practices associated with the elements, and the constraints imposed on the teachers by the Indonesian educational system.

5.2.1.1 Changing from Traditional Beliefs

My findings indicated that, initially, there was a general lack of faith in the Productive Pedagogies framework and, therefore, the teachers were reluctant to change their teaching style or try new ideas. Despite past research, that suggested that the Productive Pedagogies was a comprehensive framework (Education Queensland, 2001), the teachers remained unsure. One of the biggest concerns was related to the Western origins of the framework, which made the teachers sceptical about the relevance of the new teaching methods. The teachers needed to be convinced that the Productive Pedagogies was a reasonable teaching framework and that the elements of the framework could be applied successfully in mathematics classes in Indonesia.

This reluctance to change is consistent with past research that has suggested that teachers operate using a personal theory of teaching, or a set of beliefs about how a subject is learned and how it should be taught (Mitchell, 2005). This personal theory may be a conscious or an unconscious choice and could be based on research or reflection (Patrick & Pintrich, 2001). It is these beliefs that drive the teachers'

behaviour in the classroom including their instructional choices and actions, classroom management practices and how the teacher translates the curriculum (Eisenhart, Cuthbert, Shrum, & Harding, 1988; Luft & Roehrig, 2007; Önen, 2011;).

Teacher education programs commonly adopt theory to practice models (Pang, 1999) with the assumption that teachers will learn the theory and then apply this to practice. The relationship, however, between theory and practice is complex and influenced by many factors (Newby, 2003). Munby (1984) referred to this incongruence between what teachers think they are doing with what they are actually doing, as the 'theory-practice interface'. Newby (2003) emphasises that the assumption that the new learning "will be implemented in the classroom is both simplistic and unrealistic" (Newby, 2003, p. 14) because of the many variables that come into play.

The reluctance to change teaching styles or try new teaching methods, experienced by the four teachers, were similar to those of past studies that have examined how teachers changed their teaching style using the Productive Pedagogies framework (Bature, 2014; Alhosni, 2013; Tanko, 2012; Alsharif, 2011). For example, in his research conducted in Nigeria, Bature (2014) found that the participating teachers greeted the idea of implementing the Productive Pedagogies framework with mixed feelings. Some of the teachers were reluctant to try the ideas (feeling that this was just another research project) while others felt that there was nothing new or good that will come out of it. Still others were undecided about the implementation of the framework. The challenge of convincing teachers to make changes to their teaching threatened the success of implementing the Productive Pedagogies framework. It is recommended, therefore, that future attempts initiate the collection of published

results of studies related to the use of the Productive Pedagogies framework. In this way, evidence related to field experiences, the effectiveness and success of the implantation, as well as its challenges in relation to teaching practices could be used to help to convince the teachers (*Recommendation 1*).

5.2.1.2 Understanding the Elements

The second challenge, related to the implementation of the Productive Pedagogies framework, was teachers' understanding of the individual elements within each of the dimensions of the Productive Pedagogies framework. Although the teachers' understanding of the principles related to the different elements improved during the three action research cycles, there were still differences in the degree to which the different teachers understood many of the elements. This lack of understanding led the teachers to use inappropriate activities and, in some cases, translate the idea of the element in ways that were not consistent with the framework.

It was anticipated that the lack of understanding of the elements could have been because the five day workshop was insufficient to ensure deep understanding. These findings were similar to those of other studies that have implemented the Productive Pedagogies framework (Bature, 2014; Alhosni, 2013; and Alsharif, 2011). It is possible that spending more time on introducing the framework may develop a deeper understanding of the framework (as found by Alsharif, 2011). It is recommended, therefore, that to increase the chances of success, the introduction of the Productive Pedagogies framework should be made over a longer period of time to provide a deeper understanding of the elements (*Recommendation 2*)

It is equally possible that the teachers understanding of the elements may have been based on an existing frame of reference, which may have influenced the translation of the framework into practice. If this was the case, it is unlikely that a longer introductory work shop would be sufficient to ensure that teachers fully understood the elements. In my study, teachers were not necessarily conscious that they are reverting to their more familiar practices or that they have misinterpreted the new techniques and knowledge. These findings are supported by much past research related to teacher change(Johnson, 1994; Karavas-Doukas, 1996; Kleve, 2004; Mitchell, 2005; Pajares, 1992). The findings also corroborate past research that has found that teachers, when introduced to a new teaching approach can believe that they are implementing what is being required of them even though they may not be doing so in practice (Kleve, 2004;Karavas-Doukas, 1996). It is recommended, therefore, that future attempts to implement the Productive Pedagogy framework include more examples and illustrations, relevant to the Indonesian context, and increased opportunities to observe and practice the elements, to assist teachers to comprehend and deeply understand the framework and how it applies to their teaching (*Recommendation 3*).

My own findings corroborated past research that has indicated that, during professional development and training teachers have been found to be receptive to learning new methods, however, “when they return to their classrooms they misinterpret the new ideas and translate them to conform to existing classroom routines, at the same time believing that they are doing what the new approach calls for” (Karavas-Doukas, 1996, p. 187). Given the increased success experienced by the teachers over the course of the action research cycles, it is recommended that future

attempts to implement the Productive Pedagogies framework be accompanied by action research over a longer period of time (*Recommendation 4*).

5.2.1.3 Lack of Skills and Experience

The third challenge experienced by teachers was related to their lack of skills and experience with respect to planning lessons and organising activities that involved the various elements of the Productive Pedagogies framework. The teachers found that the multifaceted nature of the elements difficult to plan for and implement. As such, when they felt that an element was difficult to implement they tended to avoid it.

Teachers felt that the abstract nature of mathematical concepts made it difficult for them to create and plan mathematics lessons which took into consideration students' prior knowledge and were relevant to the students' experiences. Although it is widely recognised that connecting mathematics to the world beyond the classroom enhances students' understanding of mathematics concepts and strengthens their understanding (Gainsburg, 2008; Sawyer, 2008), these teachers had never done this in practice. My findings are similar to those of past studies. In particular, Chinnappan (2008) found that teachers lacked sufficient understanding the elements of the framework and what they looked like in practice to be able to plan for them effectively.

These findings corroborate past research that has found that knowledge about teaching is best informed by teaching experience. According to Darling-Hammond and McLaughlin (1995, p. 597), activities which aim to develop teachers "should

provide occasions for teachers to reflect critically on their practice and to fashion new knowledge and beliefs about content, pedagogy and learners". Based on these findings, it is recommended that, to effectively improve teachers' skills and experiences, introducing the Productive Pedagogies framework to the teachers should be include a larger practical component (to complement the theoretical component). The practical component could usefully provide exercises and practice sessions that give the teachers the opportunity to develop and practice each element of the framework (*Recommendation 5*).

5.2.1.4 Educational System

The fourth challenge experienced by teachers as they implemented the Productive Pedagogies framework was the pressure experienced by teachers because of the large amount of content that was required to be covered in the Indonesian mathematics curriculum. The introduction of lessons using productive learning experiences, coupled with developing strategies (new to both the teachers and the students) meant that teachers often found it difficult to incorporate all of the ideas into their lessons. The constraints, put on them by the examination-driven education system meant that they did not have the freedom to implement the elements well. Even though the teachers became more cognisant of the benefits of incorporating the elements of the Productive Pedagogies framework (over the course of the three action research cycles), they also recognised that, by including them, they would place pressure on an already full curriculum. My study found that the crowded curriculum meant that teachers were less likely to connect mathematics to real life situations and revolve around more abstract and de-contextualized mathematics knowledge.

My findings were similar to those of other studies that have examined problems related to moving to a more student centred teaching style (Aldridge, Fraser & Huang, 1999; Alhosni, 2013; Bature, 2014; and Alsharif, 2011). For example, in her research conducted in Oman, Alhosni (2013) found that the time constraints did not give teachers the flexibility and desire to change their practices and to apply new ideas. It is recommended that, to make educational reform more effective, introducing and implementing the Productive Pedagogies framework in schools needs to involve support from a range of stakeholders within the education sector (*Recommendation 6)*. Further it is recommended that future studies examining the implementation of the productive pedagogies framework investigate whether student achievement outcomes are improved to provide further weight to the introduction of the framework as a mechanism for reform (*Recommendation 7*).

5.2.2 Making the Changes: Reflection on Teaching

My findings indicated that the Productive Pedagogies framework was an effective tool to guide teachers in their reflections. By using the framework to guide their reflections, they were able to evaluate the effectiveness of their teaching strategies and the degree to which they had achieved their goals. The teachers felt that the Productive Pedagogies framework helped them to better understand what was required in order to be more effective. Further, the Productive Pedagogies framework helped the teachers to examine their teaching from different perspectives.

After the three action research cycles, teachers felt that, by using and reflecting on the elements of the Productive Pedagogies framework, they were able to shift their

practices. It would appear that the use of critical self-reflection on the part of the teachers, using the Productive Pedagogies framework as a guide, may well have been instrumental in terms of the improvements in teaching observed over the three action research cycles.

My findings corroborate past research that suggests that critical self-reflection can both help reinforce an individual's commitment to a particular method (which has been successful) and challenge existing perspectives which results in changes in practice (Merriam & Caferella, 1999). According to Jay and Johnson (2002), teachers go through three stages of reflection, these being description (deciding on the core of the reflection), comparison (examining teaching from different frame works) and critical (during which teachers make sense of the different view poins and develop a new frame of reference). It is at this stage that the teacher makes a decisions.

Given the connection between teacher's beliefs and reflection, which indicates that existing understandings serve as a lens for interpreting events and influence the way that teachers make decisions in the classroom (Calderhead, 1989), it would appear that the reflection component of this study was critical to bringing about the change required to implement the Productive Pedagogies framework successfully. It is recommended, therefore, that future professional development and attempts to implement the Productive Pedagogies Framework involve critical self-reflection used in the present study (*Recommendation 8).*

5.2.3 Effectiveness of Using the Productive Pedagogies Framework to Reform Mathematics Teaching

The reform of the teaching of mathematics is a current concern for many countries (Simon, 2008). There are, however, debates centred on the issue of the effectiveness of reform programs in terms of changing classroom practices (Atweh, 2004). Reform efforts must endeavour to provide teachers with different theories and knowledge about teaching so that they can apply this knowledge in the classroom. However, the professional development of teachers would appear to face a number of challenges, some of which were discussed in the previous two sections. Helping teachers to link theory and practice is of concern as many programmes of reform are too theoretical to ensure a real understating of pedagogies (Jaworkski & Gellert, 2003; Stuart & Thurlow, 2001). In many cases, this theory is presented without sufficient connection to practice (Barone, Berliner, Blanchard, Casanova & McGowan, 1996).

Another challenge is that many teachers, particularly in Indonesia, rely on transmission approaches of teaching, largely as a result of their own previous learning experiences. This problem is not unique to Indonesia. According to Simon (2008), teachers in many countries that are currently embracing movements to reform the teaching of mathematics, were educated under the traditional system of mathematics instruction. Teacher education should help teachers to understand the theoretically grounded view of learning that shifts traditional conceptions of knowledge as being developed by those who are involved in the teaching and learning process (Tatto, 1999).

As discussed in the previous section, it is becoming more widely recognised that reflection is a means through which the gap between theory and practice can be bridged (Jaworski, 1998; Jaworkski & Gellert, 2003; Malara & Zan, 2002). Through a series of action research cycles, that involved the use of reflection at each stage, this study examined the effectiveness of the Productive Pedagogies framework to bring about change in the classroom in terms of improved interactions, connectedness and social justice in mathematics.

Given this past research, the third aim of the research was to investigate the effectiveness of the Productive Pedagogies framework in terms of classroom interactions, connectedness and social justice in mathematics classes. Overall, the findings suggested that, although there were differences in the extent to which the capacity of the teachers was built over the three action research cycles, all four teachers made improvements. That is, the success of the implementation of the individual elements, within the Productive Pedagogies framework, improved for all teachers in all dimensions of the framework. The findings generally support that the use of the elements of the framework enabled the teachers to develop constructive practice which was shown through improved interactions, connectedness and social justice in mathematics classrooms.

To improve the classroom interactions, the teachers focused on the elements of the Productive Pedagogies framework that would support this. By creating an environment in which students' interacted with their teacher, the students also interacted more positively and constructively with their peers. The findings indicated that the teachers attempted to improve the student to teacher interactions by moving

to a less dominant role in the classroom, welcoming students' input and appreciating all responses and increasing respect and support for the students. The teachers tried hard to include all of the members of the class in the classroom discussions by inviting more students to give their opinions, share their ideas or to make comments. They encouraged mutual respect and support among the students and treated them in ways that made them feel valued. They also attempted to provide opportunities for all students to make comments or add information in class so that incorrect or incomplete statements were made more comprehensive.

As a result of the implementation of the Productive Pedagogies framework, the students became more willing to respond to the teachers' questions and to express their ideas. Students began to raise their hands more often to answer their teachers' questions or to comment on what their peers said. The teachers encouraged this further by consciously selecting a range of students so that, regardless of that competence, background or gender, all students were given the changes to respond.

The interactions between students also became more frequent, on-task and positive. The use of cooperative learning groups, coupled with a more supportive learning environment, led to improved interactions. These interactions are important, according to Gay (2000), who argued that teachers' response to the needs of students tends to make students have a sense of inclusion, honour and also have a sense of human dignity. These changes also were in line with the social constructivist perception of students, which is based on the beliefs that teaching and learning should provide students with both the skills that enable them to be part of their society and the information that they need (Henniger, 2004). Further, these improved interactions

encouraged the students to construct their knowledge which, according to Cobb (1994), is influenced by the active individual development of the learners and the social and cultural interactions in mathematics practices.

The implementation of the Productive Pedagogies approach also saw an improvement in the degree to which the teachers made mathematics relevant to the everyday lives of their students. All four of the teachers increased the connectedness of mathematics in the classroom. They all made a point of connecting new learning to the students' prior knowledge and encouraged the students to connect the concepts within the lessons to other relevant concepts that they had learned in previous topics, thereby deepening the students' understanding of the mathematics concepts.

The teachers also tried to connect the lesson activities to the lives of their students. That is, they started to use examples that were relevant to the students and ensure that activities and projects were meaningful. The four teachers also attempted to involve students' ideas to support the learning process (something that they never did prior to the introduction of the Productive Pedagogies framework).In addition, the teachers made attempts to use illustrations and concrete examples in their lessons to make the abstract concepts easier to grasp.

Finally, the implementation of the Productive Pedagogies framework was found to enhance social justice in the mathematics classrooms. One of the most telling points, that indicated a greater degree of social justice in the mathematics classes, was the improved student engagement (discussed in the next section). All of the students,

regardless of their background or ability, were, by the end of the third action research cycle, significantly more engaged in the mathematics lessons.

The findings indicated that social justice in the mathematics classroom was enhanced in a number of ways. As discussed earlier, interactions between the students and between the teachers and the students' were improved. This improved interaction had a number of spin-offs with respect to social justice in the mathematics classrooms. The students were not only more engaged in their learning but they were also given opportunities to construct their knowledge through meaningful interactions.

The teachers no longer concentrated their efforts on the education of a select few students in the classroom. By the end of the three action research they were including all of the students and ensured that they were all meaningfully engaged during the lessons. Because the teachers made attempts to treat all students fairly regardless of their backgrounds, the students increased willingness to be engaged in class and group discussions. In all of the classes, the teachers encouraged all students to participate in learning activities by giving them work that was relevant and interesting to them. The teachers were more likely to engage students in meaningful and relevant activities. Not only were the activities more relevant to the students' everyday life (as discussed earlier) but the teachers also gave students' opportunities to select the activities that they would like to do, further enhancing the engagement of the students.

Henningsen and Stein (1997), in their investigation of the factors in mathematics classrooms that either hinder or support students' engagement, found that minority

students fail to engage in high-level mathematical tasks due to a lack of opportunities to participate in challenging mathematics learning experiences rather than to a lack of potential. Based on their research findings they recommended that teachers provide meaningful mathematics for their students. By providing a more meaningful teaching approach, the teachers, thus, engaged in a more socially just pedagogy.

5.2.4 Increased Student Engagement

The implementation of the Productive Pedagogies framework was found to increase students' engagement. It would appear that, for a number of reasons, including the increased connectedness, improved interactions and the students' involvement in the selection of topics, their engagement in mathematics lessons improved. The findings indicated that after the introduction of the Productive Pedagogies framework, there was an observable difference in students' engagement. The number of observed behaviours indicative of a negative behaviour, decreased over the three action research cycles, whilst the number of observations indicative of a positive behaviour increased.

My findings indicated that after the implementation of the Productive Pedagogies framework, students found mathematics classes to be more interesting and accessible (in terms of understanding concepts). This finding is in line with Mills et al.'s (2009) suggestion that students' work should be connected to their world.

By the end of the third action research cycle student were more excited to attend and to participate in the classes. There were incidences of students who wanted to keep

working, even after the signal for the end of the lesson. The students who, prior to the introduction of the Productive Pedagogies framework, had been quiet and appeared disengaged with the teaching and learning, appeared to become more confident in the lessons (by speaking out in group and class discussions) and more involved in the lessons. By the end of the third action research cycle, students reported that, since the teacher changed the way he or she taught, they found mathematics lessons to be more enjoyable. These findings support the work of Gonzalez, Moll and Amanti (2005) and Valenzuela (2002) who purport that education which is roodted in the needs of students has the potential to be transformative. This improved engagement, found in my study, corroborates past research that found that implementing the Productive Pedagogies framework increased classroom engagement and participation (Aveling & Hatchell, 2007; Sorin & Klein, 2002; Tanko, 2012).

5.3 Limitations

The current research has a number of limitations that need to be considered before generalising the results. The limitations related to this study are outlined below.

First, the time constraints posed by the present study constituted a major limitation. The workshop, provided to teachers to introduce the Productive Pedagogies framework, lasted for only five days. Even though these days were utilised to their fullest, there was not sufficient time for teachers to become fully conversant with the framework. To overcome this limitation, the researcher provided much support and guidance during the implementation of the framework. Ideally, the introduction of

the Productive Pedagogies might have been introduced over the course of a semester, during which time teachers could try out practices and elements in the field during the study (*Recommendation 9*).

Similarly, the teachers only had three action research cycles in which they could plan for and implement the Productive Pedagogies framework. Therefore, despite the improvements shown in the data, it is unclear as to whether these improvements would be sustained over time. It is recommended, therefore, that future studies incorporate a longitudinal study to examine whether the changes that teachers make to their planning and teaching are maintained over time (*Recommendation 10*).

A further limitation was the number of schools and participants involved in this study. Although the findings indicated that using the Productive Pedagogies framework in mathematics teaching was promising, generalising these findings to different contexts should be made with caution. It is recommended, therefore, that future studies examine the implementation of the Productive Pedagogies framework to different locations within Indonesia (*Recommendation 11).*

Another limitation was the number of teacher-participants was only four teachers, two teachers who represented mathematics teaching in a rural school and two teachers represented mathematics teaching in an urban school. Although the teacher-participants were selected carefully, the results of the study should be generalised with caution because the research subjects may not be representative of all mathematics teachers in Indonesia. It is recommended, therefore, that future studies include a larger research subjects (*Recommendation 12).*

5.4 Summary of Recommendations

Recommendation 1: Future attemptsto introduce the Productive Pedagogies framework initiate the collection of the results of studies from a range of countries to help to convince teachers of its applicability in different settings.

Recommendation 2: To increase the chances of success, the introduction of the Productive Pedagogies frameworkshould be made over a longer period of time to provide a deeper understanding of the elements.

Recommendation 3 Future attempts to implement the Productive Pedagogy framework include more examples and illustrations, relevant to the Indonesian context, and increased opportunities to observe and practice the elements, to assist teachers to comprehend and to deeply understand the framework and how it applies to their teaching.

Recommendation 4: Future attempts to implement the Productive Pedagogies framework to be accompanied by action research that is carried out over a longer period of time.

Recommendation 5: Future attempts to implement the Productive Pedagogies framework to include the provision of exercises and practice sessions that give the teachers the opportunity to develop each element of the framework.

Recommendation 6: To make educational system reform effective, introducing and implementing the Productive Pedagogies framework

in schools needs to involve all stake holders in the education sector so that they support teachers in its implementation.

Recommendation 7: Future studies investigate whether the implementation of the Productive Pedagogies framework leads to improved student achievement to add further weight to the introduction of the framework as a mechanism for reform.

Recommendation 8: Future professional development and attempts to implement the Productive Pedagogies Framework involve critical self-reflection as used in the present study.

Recommendation 9: The Productive Pedagogies framework is introduced over the course of a semester, to give teachers time teachers to practice elements in the field.

Recommendation 10: Future studies incorporate a longitudinal study to examine whether the changes that teachers make to their planning and teaching are maintained over time.

Recommendation 11: Future studies examine the implementation of the Productive Pedagogies framework to different locations within Indonesia.

Recommendation 12: Future studies include a larger study.

5.5 Significance

The significance of the research, outlined in chapter 1, is expanded here. To the best of my knowledge, this is the first study to examine the implementation of the

Productive Pedagogies framework in Indonesia. As such, my study adds to the literature on the use of Productive Pedagogies to enhance teaching and learning and builds on past studies that have implemented the framework in other countries.

The findings of the present study have the potential to make a significant contribution to the government officials and policy makers seeking to reform mathematics teaching within the Indonesian. The Act of the Republic of Indonesia Number 20, 2003, states that the national education system functions to develop the capability, character and civilisation of the nation by enhancing its intellectual capacity and developing its potential, to inspire leaders and their people to be faithful, pious and possess noble character (Depdiknas, 2003). To realise these, the system requires a conscious and well-planned effort to create progressive educational processes. As argued earlier, the Productive Pedagogies framework is in line with Indonesian policies of education and, therefore, the results of the present study could inform policy makers about how the Productive Pedagogies framework might contribute to such a process.

The results of the study have the potential to make a useful contribution to the improvement of the quality of teaching and learning in Indonesia. The success of the four teachers, by applying the Productive Pedagogies framework, has demonstrated its overall usefulness and provided lessons from which further use of the framework might build upon.

The improvements in the teaching and learning process in mathematics, shown by the four teachers as they implemented the Productive Pedagogies framework, has the

potential to inspire and encourage teachers and teacher educators. As a country that has experienced limited success in terms of reform efforts, the results of this study provide much weight to the use of an explicit and detailed framework.

The means by which teachers were successful in using the framework in this small-scale study could be of significance to future attempts to improve mathematics teaching in Indonesia. Not only are the results likely to inspire individual teachers, but they also could provide the impetus for larger-scale attempts to improve the teaching and learning processes used in mathematics classes in Indonesia.

This study is of significance to teachers (and future researchers) because, during the course of the study, the teachers developed a range of tools. Further, being involved in the study improved the teachers' ability and skills to carry out research.

The importance of social justice within the Indonesian education system is resonated in the *Pancasila*, or Five Principles. The results of my study have the potential to inform government officials, policy makers, school administrators and teachers about how social justice, through the elements of the Productive Pedagogies framework, can become a reality in mathematics classrooms. By facilitating an environment in which students learned constructively, based on their needs, and took into consideration the students' backgrounds to provide interesting, enjoyable and meaningful mathematics learning activities, they also were ensuring a more socially just classroom.

The results of the present study have the potential to be of benefit to students. The Productive Pedagogies framework encouraged teacher to develop challenging mathematics lessons with learning activities that involved higher level thinking. Further, these lessons increased student engagement on a range of levels. In doing so, the students benefited through improved motivation, excitement and enthusiasm in mathematics.

5.6 Concluding Remarks

The use of the elements of the Productive Pedagogies framework in this study encouraged the teacher-participants to critically reflect on their own teaching, both at during their planning of lessons and after teaching the lesson. This reflection provided a means of improving the quality of the teaching learning process. The findings of my study found that, in doing so, there were significant improvements in their classroom interactions, the relevance of mathematics to students' lives, social justice and students' engagement. The use of the framework over the three action research cycles saw the start of changes in teachers' beliefs (mindset) about how best to deliver teaching effectively.

My findings support the notion that, as a comprehensive model and multidimensional construct for quality teaching, the Productive Pedagogies framework, can potentially, be used to reform educational systems. The framework can be used for professional development programs (to achieve a significant changes in teachers' classroom practices), as a tool for teachers' to reflect critically on their pedagogical practices, to inform the design of quality learning experiences and to enter into dialogue with the

community of educators about issues related to education, teaching and learning in particular.

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APPENDIX 1

Permission to use the Productive Pedagogies Framework

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To: "'suhendra@postgrad.curtin.edu.au'" <suhendra@postgrad.curtin.edu.au>; "'suhendra_upi@yahoo.com'" <suhendra_upi@yahoo.com>
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APPENDIX 2

Translation of the Productive Pedagogies Framework

Productive Pedagogies Framework

(Dimensions, Items and Key Words)

KUALITAS INTELEKTUAL *(INTELLECTUAL QUALITY)*	
Berpikir tingkat tinggi *(Higher order thinking)*	Apakah berpikir tingkat tinggidan analisis kritis yang terjadi? *(Are higher order thinking and critical analysis occurring?)*
Pengetahuan yang mendalam *(Deep knowledge)*	Apakah pelajaran mencakup materi operasional yang mendalam, mendetail, atau dengan tingkat kekhususan tertentu? *(Does the lesson cover operational fields in any depth, detail or level of specificity?)*
Pemahaman yang mendalam *(Deep understanding)*	Apakah hasil kerja dan respon siswa memberikan bukti tentang pemahaman mereka terhadap konsep atau gagasan-gagasan? *(Do the work and response of the students provide evidence of understanding of concepts or ideas?)*
Percakapan yang substantif *(Substantive conversation)*	Apakah kelas membahas pola inisiasi/tanggapan/evaluasi dan mengarah pada dialog yang berkelanjutan antar siswa, dan antara guru dan siswa? *(Does classroom talk break out of the initiation/response/evaluation pattern and lead to sustained dialogue between students, and between teachers and students?)*
Problematika pengetahuan*(Knowledge problematic)*	Apakah siswa mengkritisi dan menebak teks, ide, dan pengetahuan? *(Are students critiquing and second-guessing texts, ideas and knowledge?)*
Metabahasa *(Metalanguage)*	Apakah aspek bahasa, tata bahasa, dan kosa kata teknis menjadi latardepan? *(Are aspects of language, grammar, and technical vocabulary being foregrounded?)*
KETERKAITAN *(CONNECTEDNESS)*	
Integrasi pengetahuan *(Knowledge integration)*	Apakah pelajaran melintas bidang, disiplin dan paradigm lain? *(Does the lesson range across diverse fields, disciplines and paradigms?)*
Latar belakang pengetahuan *(Background knowledge)*	Apakah ada upaya untuk mengaitkan dengan latar belakang pengetahuan siswa? *(Is there an attempt to connect with students' background knowledge?)*

Keterkitan dengan dunia keseharian *(Connectedness to the world)*	Apakah pelajaran dan pekerjaan yang ditugaskan memiliki kemiripan atau koneksi dengan konteks kehidupan nyata? *(Do lessons and the assigned work have any resemblance or connection to real life contexts?)*
Kurikulum berbasis masalah*(Problem based curriculum)*	Apakah berfokus untuk mengidentifikasi dan memecahkan masalah-masalah intelektual dan/atau dunia nyata? *(Is there a focus on identifying and solving intellectual and/or real-world problems?)*
LINGKUNGANKELAS YANG MENDUKUNG *(SUPPORTIVE CLASSROOM ENVIRONMENT)*	
Kontrol siswa *(Student control)*	Apakah siswa memiliki hak suara untuk turut menentukan langkah, arah atau hasil pembelajaran? *(Do students have any say in the pace, direction or outcome of the lesson?)*
Dukungan sosial *(Social support)*	Apakah ruang kelas merupakan lingkungan sosial yang mendukung secara positif? *(Is the classroom a socially supportive, positive environment?)*
Keikutsertaan *(Engagement)*	Apakah siswa turut terlibat dan melakukan tugas-tugasnya? *(Are students engaged and on-task?)*
Kriteria yang tersurat *(Explicit criteria)*	Apakah kriteria kinerja siswa dibuat secara tersurat? *(Are criteria for student performance made explicit?)*
Pengaturan diri *(Self-regulation)*	Apakah arah perilaku dan peraturan diri siswa tersirat atau tersurat? *(Is the direction of student behaviour and self-regulatory implicit or explicit?)*
PENGAKUAN ATAS PERBEDAAN *(RECOGNITION OF DIFFERENCE)*	
Pengetahuanyang berbudaya *(Cultural knowledges)*	Apakah beragam pengetahuan yang berbudaya ikut serta dalam kegiatan? *(Are diverse cultural knowledges brought into play?)*
Inklusivitas *(Inclusivity)*	Apakah ada upaya yang disengaja dilakukan untuk meningkatkan partisipasi semua siswa dengan latar belakang yang berbeda? *(Are deliberate attempts made to increase the participation of all students of different backgrounds?)*
Naratif *(Narrative)*	Apakah prinsip pembelajaran bersifat naratif atau ekspositori? *(Is the teaching principally narrative, or is it expository?)*

Identitas kelompok *(Group Identity)*	Apakah pembelajaran membangun rasa kebersamaan dan identitas? *(Does teaching build a sense of community and identity?)*
Kewarganegaraan *(Citizenship)*	Apakah ada upaya yang dilakukan untuk mendorong rasa kewarganegaraan yang aktif? *(Are attempts made to foster active citizenship?)*

APPENDIX 3

Observation Guide – English

No.	*Targets of Observation*	*Qualitative Comment*	*General Indicator*
1.	Teacher focuses on the importance of all students regardless of their background and perceived academic ability by presenting intellectually challenging work. (PP – Intellectual Quality)		Teacher gives students opportunities to use higher-order thinking operations within a critical framework.
			Teacher develops lesson covers operational fields in any depth, detail, or level of specificity**.**
			Teacher uses work and responses of the students to demonstrate a deep understanding of concepts or ideas.
			Teacher keeps sustained conversational dialogue among students, between teacher and students, to create or negotiate understanding of subject matter.
			Teacher gives students chances to critically examine texts, ideas, and knowledge.
			Teacher prominently gives aspects of knowledge, grammar and technical vocabulary.
2.	Teacher facilitates all students with intellectually challenging classrooms for improving academic outcomes by giving opportunities within various units of learning activities and breaking down the power imbalances between teachers and students. (PP – Supportive Classroom Environment)		Teacher gives students chances to determine specific activities or outcomes of the lesson.
			Teacher develops classroom with an atmosphere of mutual respect and support between teacher and students, and among students.
			Teacher engages students and gives them on-task during the lesson.
			Teacher explicitly develops criteria for judging the range of students performance.
			Teacher develops the direction of students behaviour implicitly and self-regulatory.
3.	Teacher encourages students' exposure to understandings of the ways in which power works to construct particular forms of domination and subordination and providing students with the skills and knowledge to act as responsible members of a democratic community. (PP – Recognition of Difference)		Teacher values non-dominant cultures.
			Teacher attempts to ensure that students from diverse background are actively engaged in learning.
			Teacher's style of teaching is principally narrative.
			Teacher builds a sense of community and identity.
			Teacher attempts to encourage student active citizenship within the classroom.
4.	Teacher creates classroom practices relevant for students by considering what students already know and interested in, related to other topics/subjects, and also develop new things with new perspectives on daily		Teacher integrates the lesson in a range of subject areas.
			Teacher explicitly creates the lesson links with students' background knowledge.
			Teacher applies activity or task connected

	life and their own cultures. (PP – Connectedness)		to competencies or concerns beyond the classroom.
			Teacher creates lesson focuses on identifying and solving intellectual and/or real-world problems.
5.	Teacher develops students' mathematical literacy and a socio-culture consciousness; treats and engages all students equally; and assess learning in a contextualized and holistic manner. (SJ –Teaching)		Teacher introduces the mathematical ideas and skills to the lesson.
			Teacher talks to students to decide on the issues to focus on.
			Teacher facilitates students to increase their consciousness and to develop a positive social and cultural identity regardless of their background.
			Teacher creates interdisciplinary units and partnerships outside of the school.
			Teacher provides students with equal rights and treats everyone fairness.
			Teacher educates equality in learning atmosphere based upon students' background.
			Teacher creates essential and open-ended questions that have both mathematical and social justice component.
			Teacher creates projects that challenge students to come up with mathematically-sound solutions to the problems that they identify.
6.	Teacher engages high level thinking mathematical literacy; involve students to decide the issue to focus on; scaffold and assess both mathematics concepts and social justice issue; and end with a great project and students' presentation that challenge students to come up with mathematically-sound solutions. (SJ – Lesson)		The lesson begins with a small activity to more complex projects.
			The lesson involves a strong mathematical framework through social justice issue(s) and principles.
			The lesson motivates students to more learn mathematics and sense of themselves as mathematicians.
			The lesson promotes students' own power as active citizens in building a democratic society.
			The lesson is ended with a great project that ties together the mathematics concepts and the social justice issues through community problem-solving projects so deepen their understanding of social justice issues.
			The assessment determines what students have learned about both mathematics concepts and about social justice issues that are in the lesson.

General comments to the classroom observation focused on how the teacher manage the teaching and learning.

APPENDIX 4

Observation Guide – Indonesian

Pedoman Observasi (Observation Guide)

Nama Guru (Name of Teacher) :
_____

Nama Sekolah (Name of School) :
_____

Hari/Tanggal (Day/Date) :
_____

No.	***Sasaran Observasi*** ***(Targets of Observation)***	***Komentar Kualitatif (Qualitative Comment)***	***Indikator Umum*** ***(General Indicator)***
1.	Guru berfokus pada pentingnya keberadaan semua siswa tanpa membedakan latar belakang dan kemampuan akademiknya melalui penyajian kegiatan yang menantang secara intelektual. (PP – Kualitas Intelektual)		Guru memberi kesempatan kepada semua siswa untuk menggunakan cara-cara berpikir tingkat tinggi di dalam kerangka kerja yang kritis (penting).
			Guru mengembangkan pelajaran yang meliputi bidang operasional dengan kedalaman, rincian, dan/atau tingkat kekhususan tertentu.
			Guru menggunakan hasil kerja dan tanggapan siswa untuk mendemonstarsikan pemahaman siswa yang mendalam tentang konsep atau gagasan.
			Guru mempertahankan keberlangsungan dialog yang berkelanjutan antar siswa, antara siswa dengan guru, untuk membuat atau menegosiasikan pemahanan materi subjek.
			Guru memberikan kesempatan pada siswa untuk menguji teks, gagasan, dan pengetahuan secara kritis.
			Guru secara jelas menyajikan pengetahuan, tata bahasa, dan kosa kata teknis.
2.	Guru memfasilitasi semua semua siswa dengan ruangan kelas yang menantang secara intelektual untuk peningkatan hasil akademik melalui pemberian kesempatan dalam unit-unit aktivitas belajar dan ‘pembongkaran’ atas ketidakseimbangan peran antara siswa dan siswa. (PP – Lingkungan Kelas yang		Guru memberikan kesempatan pada siswa untuk (turut) menentukan kegiatan atau hasil tertentu dari kegiatan pembelajaran.
			Guru membangun kelas dengan atmosfir saling menghargai dan saling mendukung di antara siswa dengan guru dan di antara siswa dengan siswa.
			Guru mendorong dan memberi siswa tugas-tugas yang sesuai selama pembelajaran berlangsung.

	Mendukung)		Guru secara eksplisit mengembangkan kriteria untuk menilai rentang kinerja siswa.
			Guru mengembangkan arah prilaku siswa secara implisit beserta pengaturan diri siswa.
3.	Guru mendorong pemikiran siswa terhadap pemahaman bagaimana kekuatan berfungsi dalam mengkonstruksi bentuk khusus dari dominasi dan subordinasi serta menyajikan pengetahuan dan keterampilan agar dapat melakukan sesuatu sebagai bentuk tanggung jawab sebagai anggota masyarakat yang demokratis. (PP – Pengakuan Atas Adanya Perbedaan)		Guru menghargai budaya kelompok-kelompok yang tidak dominan.
			Guru berusaha meyakinkan bahwa siswa dari beragam latar belakang secara aktif didorong dalam pembelajaran.
			Gaya mengajar guru secara prinsip bersifat naratif.
			Guru membangun rasa komunitas dan identitas siswa.
			Guru berusaha mendorong siswa menjadi warga yang aktif di dalam kelas.
4.	Guru menjadikan kegiatan di dalam kelas relevan bagi siswadengan mempertimbangkan apa yang telah siswa ketahui, menarik dan berkaitan dengan topik/subjek lain, serta mengembangkan hal-hal baru dengan perspektif yang berkaitan dengan kehidupan sehari-hari dan budaya siswa. (PP – Keterkaitan)		Guru mengintegrasikan pelajaran dalam sebuah rentang area subjek.
			Guru secara eksplisit mengembangkan pelajaran yang terhubungkan dengan pengetahuan latar belakang siswa.
			Guru memanfaatkan aktivitas atau tugas yang berkaitan dengan kompetensi atau kajian di luar kelas.
			Guru menjadikan pelajaran fokus pada identifikasi dan pemecahan masalah-masalah intelektual dan atau yang berkaitan dengan kehidupan sehari-hari.
5.	Guru mengembangkan literasi matematika siswa dan kesadaran sosio-kultural; memperlakukan dan mendorong semua siswa secara setara; dan mengevaluasi pembelajaran secara kontekstual dan holistik. (SJ – Pembelajaran)		Guru memperkenalkan gagasan dan keterampilan matematik ke dalam pelajaran.
			Guru mengajak siswa untuk menentukan isu yang akan menjadi fokus dalam pembelajaran.
			Guru memfasilitasi siswa untul meningkatan kesadaran serta mengembangkan identitas sosial dan kultural yang positif tanpa membedakan latar belakang mereka.
			Guru mengadakan unit-unit antar disiplin ilmu dan kerjasama dengan pihak-pihak di luar sekolah.
			Guru memberi hak dan perlakuan yang setara pada setiap siswa secara adil.
			Guru mengajarkan hakekat persamaan

			melalui atmosfir belajar berdasarkan latar belakang siswa.
			Guru menciptakan pertanyaan-pertanyaan terbuka dan esensial yang berkaitan dengan komponen matematik dan keadilan sosial.
			Guru mendorong siswa untuk menemukan baik konsep-konsep matematik maupun isu-isu keadilan sosial.
			Guru mengkreasi projek-projek yang menantang siswa agar memunculkan pemecahan masalah yang bernuansa matematik yang mereka identifikasi.
			Guru memberi kesempatan pada siswa untuk menyajikan dan berbagi hasil kerja mereka kepada orang lain.
6.	Guru mendorong literasi berpikir matem atika tingkat tinggi; melibatkan siswa untuk menentukan isu-isu yang dipilih; membangun dan menilai baik konsep-konsep matematika maupun isu-isu keadilan sosial; dan men gakhirinya dengan 'projek' dan presentasi siswa yang menantang sehingga mereka dapat memunculkan pemecahan dengan nuansa matematik (SJ – Bahan Ajar)		Pelajaran dimulai dengan aktivitas sederhana menuju aktivitas atau projek yang lebih kompleks.
			Pelajaran melibatkan kerangka matematik yang kuat melalui isu dan prinsip-prinsip keadilan sosial.
			Pelajaran memotivasi siswa agar lebih mempelajari matematika dan kepekaan sebagai matematikawan.
			Pelajaran mempromosikan kemampuan siswa sebagai warga yang aktif di dalam membangun sebuah masyarakat yang demokratis.
			Pelajaran diakhiri dengan sebuah projek yang 'besar' yang mengaitkan antara konsep-konsep matematika dengan isu-isu keadilan sosial melalui projek pemecahan masalah yang berkaitan dengan masyarakat sehingga memperdalam pemahaman siswa tentang isu-isu keadilan sosial.
			Penilaian menentukan apa yang telah siswa pelajari di dalam pelajaran yang disajikan, baik berkenaan dengan konsep-konsep matematika maupun isu-isu keadilan sosial.

Komentar umum pada observasi di dalam kelas yang berfokus pada bagaimana guru mengelola pembelajaran.

APPENDIX 5

Observation Checklist – Teacher

Observation Checklist for Teachers

Name of Teacher : _____
Teaching Experience : _____
Name of School : _____
Date : _____

No.	Observed Object	Yes	No	Qualitative Comment
	Intellectual Quality			
1	Teacher gives students opportunities to use higher-order thinking operations within a critical framework			
2	Teacher develops lesson covers operational fields in any depth, detail, or level of specificity			
3	Teacher uses work and responses of the students to demonstrate a deep understanding of concepts or ideas			
4	Teacher keeps sustained conversational dialogue between students, between teacher and students, to create or negotiate understanding of subject matter			
5	Teacher gives students chances to critically examine texts, ideas, and knowledge			
6	Teacher prominently gives aspects of knowledge, grammar and technical vocabulary			
	Supportive Classroom Environment			
7	Teacher gives students chances to determine specific activities or outcomes of the lesson			
8	Teacher develops classroom with an atmosphere of mutual respect and support between teacher and students, and among students			
9	Teacher engages students and gives them on-task during the lesson			
10	Teacher explicitly develops criteria for judging the range of students performance			
11	Teacher develops the direction of students behaviour implicitly and self-regulatory			
	Recognition of Difference			
12	Teacher values non-dominant cultures			
13	Teacher attempts to ensure that students from diverse background are actively engaged in learning			
14	Teacher's style of teaching is principally narrative			
15	Teacher builds a sense of community and identity			
16	Teacher attempts to encourage student active citizenship within the classroom			
	Connectedness			
17	Teacher integrates the lesson in a range of subject areas			
18	Teacher explicitly creates the lesson links with students' background knowledge			
19	Teacher applies activity or task connected to competencies or concerns beyond the classroom			
20	Teacher creates lesson focuses on identifying and solving intellectual and/or real-world problems			

General comments on classroom observation focused on teacher:

APPENDIX 6

Observation Checklist – Student

Observation Checklist for Students

Name of Teacher : _____
Name of School : _____
Date : _____

No.	Observed Object	Yes	No	Qualitative Comment
	Intellectual Quality			
1	Students use higher-order thinking operations within a critical framework			
2	The work and responses of the students demonstrate a deep understanding of concepts or ideas			
3	There is sustained conversational dialogue between students, between teacher and students, to create or negotiate understanding of subject matter			
4	Students critically examine texts, ideas, and knowledge			
	Supportive Classroom Environment			
5	Students determine specific activities or outcomes of the lesson			
6	There is an atmosphere of mutual respect and support between teacher and students, and among students			
7	Students engage and on-task during the lesson			
	Recognition of Difference			
8	Students from diverse background actively engage in learning			
9	Students express a sense of community and identity			
10	Students encourage active citizenship within the classroom			
	Connectedness			
11	Students' activities focus on identifying and solving intellectual and/or real-world problems			

General comments on classroom observation focused on students:

APPENDIX 7

Interview Guide – Students

Interview Guide for Students

Name of Student : _____
(or Group of Students)
Name of Teacher : _____
Name of School : _____
Date : _____

*) This interview contains questions about your mathematics lesson. You will be asked to state your opinion regarding each practice takes place. There are no 'right' or 'wrong' answers because this is NOT a test that will score you, only your opinion is what is wanted.

No.	Research Aims	Questions	General Indicators
1	The **effect** of such a program on:		
	a) students' development of **mathematical knowledge**	What are the effects of teaching and learning method your teacher used on your mathematical knowledge?	1) Did the lesson you attended connect the new mathematics concepts to previous mathematics concepts you have learned? 2) Do you understand the topic of mathematics lesson you attended? 3) Are there any parts of the topic unclear for you? 4) Did the lesson make you think mathematics more deeply? 5) Did the lesson make you recognise the power of mathematics as an important tool to understand and change our life? 6) Did the lesson consist of activities that challenge you to come up with mathematical solutions to the problems that you identify? 7) Did the lesson involve mathematics ideas, concepts and principles into issue in the lesson? 8) Did the lesson encourage you to scaffold both mathematics concepts and issues in the lesson? 9) Did the lesson is ended with a great project that ties mathematics concepts and issues in the lesson?
	b) students' **engagement** in teaching and learning of mathematics	What was the teaching method your teacher used engage you in learning mathematics?	10) Did the lesson make you happy to learn mathematics? 11) Did your teacher motivate and challenge you to learn more mathematics? 12) Did your teacher involve students to decide on the issues to focus on? 13) Did the lesson provide out of the classroom learning activities? 14) Did your teacher give you opportunity to present and share your work to your friends and others? 15) Do you feel easier to learn mathematics you're your teacher's teaching method? 16) What are your impressions toward the teaching and learning you attended?
2	The development of students' **awareness about social justice issues** through mathematics	After attending the mathematics lesson, do you understand and aware about issues discussed in the lesson? What do you	17) Did your teacher make all of students involve in the mathematics lesson? 18) Did your teacher clearly create the lesson links with your background? 19) Did your teacher give students chances to

		get from the mathematics lesson you attended?	determine specific activities of the lesson? 20) Did your teacher give all of students an equal chance to participate in mathematics lesson? 21) Did your teacher provide students equal rights and treat every student in the class fairly? 22) Did your teacher develop classroom with mutual respect and support between teacher and students, and among students? 23) Did your teacher keep conversational dialogue among students, and between teacher and students? 24) Did your teacher make students enable to deepen their understanding of local, national, and global issues? 25) Did you feel that students from diverse background are actively engaged in teaching and learning
3	The **influences of background** of the students on teaching and learning	What were the influences of students' socioeconomic background on teaching and learning?	26) Did your teacher educate equality during the learning you attended? 27) Were there students who face difficulties during teaching and learning? 28) How did your teacher encourage students who have difficulties on the teaching and learning?

APPENDIX 8

Interview Guide –Teachers

Interview Guide for Teachers

Name of Teacher : _____
Name of School : _____
Date : _____

No.	Research Aims	Questions	General Indicators
1	The **effect** of such a program on:		
	a) students' development of **mathematical knowledge**	What are the effects of teaching and learning mathematics approach you used on students' development of mathematical knowledge?	1) Did the program connect the new mathematics concepts to previous mathematics concepts that students have learned? 2) Did the program make students develop critical thinking and problem-solving skills of mathematics? 3) Did the program apply mathematical open-ended (essential) questions? 4) Did the program make students recognise the power of mathematics as an essential tool to understand and change their life? 5) Did the program create activities that challenge students to come up with mathematically-sound solutions to the problems that they identify? 6) Did the program increase students' mathematics literacy? 7) Did the program, through social justice issue(s) and principles, involve a strong mathematical framework? 8) Did the program encourage students to scaffold mathematics concepts ?
	b) students' **engagement** in teaching and learning of mathematics	What are the effects of teaching and learning mathematics approach you used on students' engagement in teaching and learning mathematics?	9) Did the program create teaching and learning focuses on identifying and solving intellectual and/or real-world problems 10) Did the program make students challenged with teaching and learning of mathematics? 11) Did the program involve students to decide on the issues to focus on? 12) Did the program engage students in mathematical high-level thinking? 13) Did the program engage students and give them on-task during the lesson? 14) Did the program apply learning activities connected to competencies or concerns beyond the classroom? 15) Did the program motivate students to more learn mathematics and sense of themselves as mathematicians? 16) Did the program is ended with a great project that ties mathematics concepts and social justice issues through community problem-solving projects? 17) Did the program create interdisciplinary units and partnerships outside of the school? 18) Did the program give students opportunity to present and share their work to others?
2	The development of students' **awareness about social justice issues** through	How did you develop students' awareness of social justice issues through mathematics?	19) Did the teacher make all of students involve in the mathematics lesson? 20) Did the teacher explicitly create the lesson links with students' background?

	mathematics		21) Did the teacher give students chances to determine specific activities or outcomes of the lesson? 22) Did the teacher give all of students an equal chance to participate in mathematics lesson? 23) Did the teacher provide students equal rights and treat every student in the class fairly? 24) Did the teacher give students chances to critically examine texts, ideas, and knowledge? 25) Did the teacher develop classroom with an atmosphere of mutual respect and support between teacher and students, and among students? 26) Did the teacher keep sustained conversational dialogue among students, between teacher and students, to create or negotiate understanding of subject matter 27) Did the teacher make students enable to deepen their understanding of local, national, and global social justice issues? 28) Did the program encourage students to scaffold both mathematics concepts and social justice issues? 29) Did you attempt to ensure that students from diverse background are actively engaged in teaching and learning 30) Did the teacher promote students' own power as active citizens in building a democratic society?
3	The **influences of background** of the students on teaching and learning	What were the influences of students' background on teaching and learning?	31) Did the teacher educate equality in learning atmosphere based upon students' social economic background? 32) Did the teacher value non-dominant cultures? 33) Did socioeconomic background of students influence them on teaching and learning? 34) Did students from low socioeconomic background have difficulties on teaching and learning process? 35) How did you do to encourage students from low socioeconomic background on teaching and learning?
4	The **teachers' perception** of the use of Productive Pedagogies in the teaching and learning of mathematics	What are your impression and opinion about the use of Productive Pedagogies in teaching and learning of mathematics?	36) How effective the use of the teaching approach by applying Productive Pedagogies in the teaching and learning of mathematics? 37) What are the difficulties and obstacles encountered when you taught the mathematics lesson (if any)? 38) Do you feel easier to engage student in teaching and learning of mathematics by using this approach? 39) What are your students' impressions toward the teaching and learning approach you used to deliver the lesson?

APPENDIX 9

Ethics Approval

Curtin University

Memorandum

To	Suhendra, SMEC
From	Pauline Howat, Administrator, Human Research Ethics Science and Mathematics Education Centre
Subject	Protocol Approval **SMEC-04-12**
Date	8 February 2012
Copy	Bill Atweh, SMEC

Office of Research and Development

Human Research Ethics Committee

Telephone 9266 2784
Facsimile 9266 3793
Email hrec@curtin.edu.au

Thank you for your "Form C Application for Approval of Research with Low Risk (Ethical Requirements)" for the project titled *"Reforming mathematics education through productive pedagogies with focus on social justice"*. On behalf of the Human Research Ethics Committee, I am authorised to inform you that the project is approved.

Approval of this project is for a period of twelve months **25th January 2012** to **24th January 2013**.

The approval number for your project is **SMEC-04-12**. *Please quote this number in any future correspondence.* If at any time during the twelve months changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately.

Pauline

PAULINE HOWAT
Administrator
Human Research Ethics
Science and Mathematics Education Centre

Please Note: The following standard statement must be included in the information sheet to participants:
This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number SMEC-04-12). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784 or hrec@curtin.edu.au

APPENDIX 10

Information Sheet – Students

Curtin University
Science and Mathematics Education Centre(SMEC)

Students' Information Sheet

Dear Students,

*My name is **Suhendra.** I am currently working on my Doctor of Philosophy in Mathematics Education at SMEC (Science and Mathematics Education Centre), Curtin University of Technology, Perth, Western Australia, Australia.*

Purpose of Research
I am working on a research with topic ***"Reforming Mathematics Education through Productive Pedagogies"***

Your Role
I am seeking your permission to use you as a subject for my research, and your will be that you will be willing to discuss with me during a focus-group and in-depth interviews as well as discussions and also ask you for interviews whenever I come to your class or you are invited for that purpose.

Consent to Participate:
Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. If you are interested to participate in this research, you indicate your willingness in writing through the email below.

Confidentiality:
The information you provided will be kept separate from your personal details, and only myself and my supervisor will have access to the information. The focus-groups and in-depth interviews as well as discussions transcript will not have your name or any other identifying information on it and in adherence to Curtin University policy, transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information
This research has been reviewed and given approval by Curtin University Human Research Ethics Committee. If you would like further information about the study, please feel free to contact me, **Suhendra** – SMEC (Science and Mathematics Education Centre), Curtin University, PO Box U198, Perth WA 6845
Email: suhendra@student.curtin.edu.au*or*suhendra_upi@yahoo.com
Phone: +61450427086
Alternatively, you can contact my supervisor,
Associate Professor **Bill Atweh** – SMEC (Science and Mathematics Education Centre), Curtin University, PO Box U1987, Perth WA 6845,
Phone: +61 (0)8 9266 7073
Fax: +61 (0)8 9266 2503
Email: b.atweh@curtin.edu.au

Thank you very much for your involvement in this research. Your participation is greatly appreciated.
Suhendra (14244575)

APPENDIX 11

Information Sheet – Teachers

INFORMATION FOR RESEARCH PARTICIPANTS

Curtin University
Science and Mathematics Education Centre(SMEC)

Teachers' Information Sheet

Dear Sir/Madam,

My name is **Suhendra.** I am currently working on my Doctor of Philosophy in Mathematics Education at SMEC (Science and Mathematics Education Centre), Curtin University of Technology, Perth, Western Australia, Australia.

Purpose of Research
I am working on a research with topic ***"Reforming Mathematics Education through Productive Pedagogies"***

Your Role
I am seeking your permission to use you as a subject for my research, and your role in the research:

1) That you will be willing to attend in five-day workshop sessions on the Productive Pedagogies framework and on strategies for data collection.
2) That you will be willing to be a subject to be observed by myself as the researcher and other participating teachers and, who are working with you on similar topics, hence, will use you as their subject during the research.
3) That you will also be willing to observe other participating teachers during the research as a means of obtaining data from them. This will involve classroom observation and reflection on teaching.
4) Due to the research is in a community of practice, there will be reflection meetings with other participating teachers, classroom observations, and report writing, on the introduction of the Productive Pedagogies framework in the mathematics classroom. Hence, you will be willing to make yourself available for these meetings.
5) That you will be conducting your own research, working on the Productive Pedagogies framework while I serve as a facilitator monitoring and guiding you on how the research will be conducted, and the data generated will be yours.
6) You will be working with three other teachers, on your own research topic for teaching mathematics your class using the Productive Pedagogies framework.

Consent to Participate
Your participation in this research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. I shall be grateful to receive your response on your willingness to participate in writing through the email address below, so that we can make a final decision on those who will be participating. This should include a brief resume and your research experience. If you do not have any, you can still indicate your interest as this is a law in Australian Universities.

Confidentiality
The information you provided in this research will be kept separate from your personal details, and only myself and my supervisor will have access to them. The focus-group interviews and discussions transcript will not have your name or any other identifying information on it and in adherence to Curtin University policy, transcribed information will

be kept in a locked cabinet for at least five years, before a decision is taken as to whether it should be destroyed.

Further Information:
This research has been reviewed and given approval by Curtin University Human Research Ethics Committee. If you would like further information about the study, please feel free to contact me, **Suhendra** – SMEC (Science and Mathematics Education Centre), Curtin University, PO Box U198, Perth WA 6845
Email: suhendra@student.curtin.edu.au *or* suhendra_upi@yahoo.com
Phone: +61450427086
Alternatively, you can contact my supervisor,
Associate Professor **Bill Atweh** – SMEC (Science and Mathematics Education Centre), Curtin University, PO Box U1987, Perth WA 6845
Phone: +61 (0)8 9266 7073
Fax: +61 (0)8 9266 2503
Email: b.atweh@curtin.edu.au

Thank you very much for your involvement in this research. Your participation is greatly appreciated.
Suhendra (14244575)

APPENDIX 12

Information Sheet – Principals

Curtin University
Science and Mathematics Education Centre(SMEC)

Principals' Information Sheet

Dear Sir/Madam,

*My name is **Suhendra.** I am currently working on my Doctor of Philosophy in Mathematics Education at SMEC (Science and Mathematics Education Centre), Curtin University of Technology, Perth, Western Australia, Australia.*

Purpose of Research
I am working on a research with topic ***"Reforming Mathematics Education through Productive Pedagogies"***

Your Role
I am seeking your permission to conduct research in your school and also your indulgence in the following areas of support:
1) Asking for your support to make this research a success.
2) Asking for your mathematics teachers that are willing to participate in the workshop to avail themselves with this opportunity of learning new teaching model to classroom instruction using the Productive Pedagogies framework.
3) Asking for students to participate in a focus-group and in-depth interviews with respect their perception on the reform on mathematics classroom practice using the Productive Pedagogies framework.

However, I need to mention here that the research will in no wise **interfere** with official duties during the term as the participating teachers will follow the terms' school timetable to teach your students.

Consent to Participate
The students and your involvement in this research are entirely voluntary. You have the right to withdraw yourself and or any of your student-participants from this research at any stage without it affecting your rights or my responsibilities. I will be very grateful if you can consent to this in writing as this is one of the criteria for all researchers in Australian Universities.

Benefits
1) This research will afford your school the opportunity to be the starting and reference point for the introduction of the Productive Pedagogies framework in Indonesia.
2) The Productive Pedagogies framework is a new teaching paradigm in Indonesia. Applying this will give your school the opportunity to developed positive attitude towards mathematics classroom instructions as this had been the problem to most mathematics classrooms in Indonesia, even across countries around the world.
3) Mathematics education, in particular teaching and learning process had been criticised as being not well taught or learnt. This has resulted to students' low grades score every year at all levels of education in Indonesia. Therefore, if this is well implemented, it is believed that it will contribute to solve the problem of teaching and learning of mathematics.

Confidentiality
The information you provided in this research will be kept separate from your personal details, and only myself and my supervisor will have access to them. The focus-groups and in-depth interviews as well as discussions transcript will not have your name or any other identifying information on it and in adherence to Curtin University policy, transcribed information will be kept in a locked cabinet for at least five years, before a decision is taken as to whether it should be destroyed.

Further Information
This research has been reviewed and given approval by Curtin University Human Research Ethics Committee. If you would like further information about the study, please feel free to contact me, **Suhendra** – SMEC (Science and Mathematics Education Centre), Curtin University, PO Box U198, Perth WA 6845
Email: suhendra@student.curtin.edu.au *or* suhendra_upi@yahoo.com
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Alternatively, you can contact my supervisor,
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Thank you very much for your involvement in this research. Your participation is greatly appreciated.
Suhendra (14244575)

APPENDIX 13

Sample Lesson Plan

RENCANA PELAKSANAAN PEMBELAJARAN (RPP)

Nama Sekolah : ... *) *Omitted*
Mata Pelajaran : Matematika
K e l a s : VII (Tujuh)
Semester : 1 (Satu)

Standar Kompetensi : **Bilangan**
1. Memahami sifat-sifat operasi hitung bilangan dan penggunaannya dalam pemecahan masalah

Kompetensi Dasar : 1.1. Melakukan operasi hitung bilangan bulat dan pecahan
Alokasi Waktu : 4 Jam Pelajaran (2 x Pertemuan)

A. Tujuan Pembelajaran

1. *Pertemuan Pertama*
   a) Peserta didik dapat memberikan contoh bilangan bulat
   b) Peserta didik dapat menentukan letak bilangan bulat dalam garis bilangan
2. *Pertemuan Kedua*
   a) Peserta didik dapat melakukan operasi penjumlahan, pengurangan, perkalian, dan pembagian bilangan bulat termasuk operasi campuran
   b) Peserta didik dapat menaksir hasil perkalian dan pembagian bilangan bulat

- *Karakter peserta didik yang diharapkan* :
  - Berdisiplin
  - Tekun
  - Bertanggung jawab
  - Mempunyai rasa hormat pada orang lain

B. Materi Ajar

Bilangan bulat yang meliputi:
1. Mengenal bilangan bulat negatif dan lawan bilangan bulat
2. Menjumlah, mengurang, mengali, dan membagi bilangan bulat
3. Menaksir hasil perkalian dan pembagian bilangan bulat

C. Metode Pembelajaran

1. Tanya jawab
2. Diskusi
3. Pemberian tugas

D. Kegiatan Pembelajaran

1. Pertemuan Pertama

a) Kegiatan Pendahuluan
   - Menyampaikan tujuan pembelajaran
   - Apersepsi
   - Memotivasi peserta didik tentang pentingnya materi ini

a) Kegiatan Inti
   - *Eksplorasi*

   Dalam kegiatan eksplorasi

- guru meminta peserta didik secara bergiliran untuk memberikan contoh bilangan bulat dan lawannya
- guru meminta peserta didik secara bergiliran untuk memberikan contoh penggunaan bilangan bulat dalam kehidupan sehari-hari dan meminta siswa lain untuk mengomentarinya
- guru meminta peserta didik untuk menggambar garis bilangan dan memilih sejumlah bilangan bulat secara bebas, kemudian peserta didik diminta untuk menentukan letak bilangan-bilangan bulat tersebut pada garis bilangan

▪ *Elaborasi*

Dalam kegiatan elaborasi,

- guru meminta peserta didik mengelaborasi hal-hal yang berkaitan dengan bilangan bulat (bilangan bulat positif, bilangan cacah, bilangan bulat negatif, penentuan letak bilangan bulat dalam garis bilangan, pengurutan bilangan bulat, dan penggunaan bilangan bulat) secara bergiliran
- guru memfasilitasi peserta didik melalui diskusi untuk memunculkan gagasan baru berkaitan dengan bilangan bulat secara lisan maupun tulisan
- guru memfasilitasi peserta didik untuk mengelaborasi hasil belajar pada tahap sebelumnya (eksplorasi)

▪ *Konfirmasi*

Dalam kegiatan konfirmasi,

- guru mengkonfirmasi hasil belajar peserta didik pada tahap sebelumnya (eksplorasi dan elaborasi) melalui pertanyaan
- guru memfasilitasi peserta didik untuk melakukan refleksi terhadap pengalaman belajar sebelumnya
- guru memberikan umpan balik dan penguatan kepada peserta didik, baik secara lisan, tulisan, dan memberikan *reward* terhadap hasil belajar yang peserta didik tunjukan
- guru memfasilitasi peserta didik untuk menyajikan hasil kerja individual dan mempresentasikan hasil kegiatan di dalam kelompoknya masing-masing
- guru meminta peserta didik untuk membuat resume materi kegiatan yang telah dilakukan, baik secara individual maupun kelompok

b) Kegiatan akhir

Dalam kegiatan penutup,

- guru bersama dengan peserta didik membuat kesimpulan materi pelajaran
- guru bersama dengan peserta didik merencanakan kegiatan tindak lanjut pembelajaran

2. Pertemuan Kedua

a) Kegiatan Pendahuluan

- Menyampaikan tujuan pembelajaran
- Apersepsi
- Memotivasi peserta didik tentang pentingnya materi ini

b) Kegiatan Inti

▪ *Eksplorasi*

Dalam kegiatan eksplorasi,

- guru meminta peserta didik untuk menjawab pertanyaan berkaitan dengan materi ajar yang telah mereka pelajari pada pertemuan sebelumnya
- guru memberikan stimulus kepada peserta didik secara bergiliran untuk menunjukan pemahamannya terhadap operasi penjumlahan, pengurangan, perkalian, dan pembagian bilangan bulat termasuk operasi campuran dikaitkan dengan pengalaman peserta didik dan kehidupan sehari-hari

- guru bersama dengan peserta didik membahas contoh mengenai cara menjumlahkan bilangan bulat dengan bantuan garis bilangan, cara menjumlahkan bilangan bulat dengan model koin, dan cara mengurangkan bilangan bulat dengan bantuan garis bilangan dan model koin
- guru secara bergiliran meminta peserta didik untuk melakukan operasi penjumlahan dan pengurangan (dengan garis bilangan atau model koin), perkalian, dan pembagian bilangan bulat termasuk operasi campuran

▪ *Elaborasi*

Dalam kegiatan elaborasi,

- guru meminta peserta didik untuk menunjukkan pemahaman peserta didik tentang penjumlahan dan pengurangan bilangan bulat dengan menggunakan garis bilangan dan model koin, serta pengurangan bilangan bulat dengan menggunakan garis bilangan dan model koin
- guru bersama peserta didik membahas: penjumlahan bilangan bulat dengan menggunakan garis bilangan dan model koin serta sifat-sifat pada operasi penjumlahan; pengurangan bilangan bulat dengan menggunakan garis bilangan dan model koin serta sifat-sifat pada operasi pengurangan
- guru meminta peserta didik untuk mendiskusikan beberapa soal mengenai perkalian dua bilangan bulat yang bertanda sama dan berbeda tanda
- guru meminta peserta didik untuk menelusuri pemahaman peserta didik tentang operasi campuran, pola bilangan, perkalian bilangan bulat, dan pembagian bilangan bulat melalui pertanyaan terbuka, kemudian peserta didik dan guru secara bersama-sama membahas dan mendiskusikannya
- guru memfasilitasi peserta didik melalui pemberian tugas, diskusi, dan lain-lain untuk memunculkan gagasan baru baik secara lisan maupun tertulis
- guru meminta peserta didik untuk membuat catatan kegiatan yang telah dilakukan, baik secara individual maupun kelompok

▪ *Konfirmasi*

Dalam kegiatan konfirmasi,

- guru mengkonfirmasi hasil belajar peserta didik pada tahap sebelumnya (eksplorasi dan elaborasi) melalui pertanyaan
- guru memfasilitasi peserta didik melakukan refleksi terhadap pengalaman belajar sebelumnya
- guru memberikan umpan balik dan penguatan kepada peserta didik, baik secara lisan, tulisan, dan memberiikan maupun hadiah (*reward*) terhadap hasil belajar yang peserta didik tunjukan
- guru memfasilitasi peserta didik untuk menyajikan hasil kerja individual dan mempresentasikan hasil kegiatan di dalam kelompok masing-masing
- guru bersama peserta didik memastikan kesalahan pemahaman, memberikan penguatan dan menyimpulkan apa yang telah dipelajari
- guru meminta peserta didik untuk mengkomunikasikan secara lisan apa yang telah dibahas di dalam kelompoknya masing-masing
- guru meminta peserta didik untuk mempresentasikan hasil diskusi kelompoknya di depan kelas secara bergantian
- guru meminta peserta didik untuk membuat resume materi kegiatan yang telah dilakukan, baik secara individual maupun kelompok

c) Kegiatan akhir

Dalam kegiatan penutup,

- guru bersama dengan peserta didik membuat kesimpulan materi pelajaran
- guru bersama dengan peserta didik merencanakan kegiatan tindak lanjut pembelajaran

E. Sumber dan Alat Belajar

1. ***Sumber Belajar***

a) Buku paket Matematika Kelas VII Semester 1

b) Buku referensi lain

2. ***Alat Belajar***

a) Laptop

b) LCD

c) OHP

F. Penilaian Hasil Belajar

Indikator Pencapaian Kompetensi	*Penilaian*		
	Teknik Penilaian	*Bentuk Instrumen*	*Instrumen/Soal*
* Memberikan contoh bilangan bulat * Menentukan letak bilangan bulat dalam garis bilangan * Melakukan operasi penjumlahan, pengurangan, perkalian, dan pembagian bilangan bulat termasuk operasi campuran * Menaksir hasil perkalian dan pembagian bilangan bulat	Tes tertulis	Tes uraian	1. Buat sebuah garis bilangan. Letakkan bilangan-bilangan berikut ini: -16, 9, -8, 0, 14, -1, -22, 13, 4, 10 pada garis bilangan yang telah kamu gambar 2. Cermati bilangan-bilangan berikut: -17, 35, -24, 43, -8, 0, 13. a) Tuliskan lawan dari masing-masing bilangan tersebut b) Kurangkan bilangan ketiga dari bilangan kelima c) Berapakah selisih antara bilangan terbesar dan bilangan terkecil? 3. Jelaskan bagaimana proses mendapatkan hasil pengerjaan operasi bilangan-bilangan di bawah ini! a) 18 + (-26) + (-8) b) -24 – (-30) – 15 c) 13 – (-5 + 27) x 4 d) 18 – (-24) : (-3) 4. Dalam sebuah turnamen sepakbola terdapat 10 tim yang bertanding. Apabila sebuah tim menang diberi nilai 2, kalah diberi nilai -1, dan apabila seri diberi nilai 0. Salah satu tim telah bermain sebanyak 35 kali dengan rincian 17 kali menang, 5 kali kalah, dan 8 kali seri. Berapakah nilai yang diperoleh tim tersebut?