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LEARNERS' IDENTITY IN MATHEMATICS

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A dissertation submitted to the Faculty of Humanities, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master of Education.

Johannesburg

2017

DECLARATION

I declare that this dissertation is my own unaided work. It is being submitted for the degree of Master of Education at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other university.

_ _ _ _ _ _ _ _ _

Wanda Masondo

7th Day of April, 2017

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ABSTRACT

The study reported in this dissertation sought to explore Grade 8 learners' identities in mathematics. The study focused on examining learners' interpretations of their relationships with the discipline of mathematics. The study drew on ideas from three different yet complementing theoretical perspectives as advocated by Gee (2001), Wenger (1998), and Sfard and Prusak (2005). However, Wenger's (1998) broader social theory of learning was selected as a theoretical framework of this study to particularly connect the process of active engagement and participation in the practices of social communities and explain the construction of learners' identity in mathematics.

The study refuted a view that mathematics learners are born with special genes which drive them to succeed in doing the subject. This stance permitted the study to divert from discussing the role of models of abilities when doing mathematics or what Darragh (2016) described as a 'performative identity'. Rather, the study was inclined to look at relationships between emotional and cognitive reactions that shift from time to time whenever mathematics is made accessible for learners through participatory pedagogy which encourages exploration, negotiation and ownership of knowledge.

The study employed mixed methods research. The reasons for employing mixed methods research included the researcher's beliefs and that the research questions were both exploratory and confirmatory type of questions. The research used a sequential mixed methods design. In the first phase, data sets were collected and analysed from an open-ended questionnaire (qualitative component). The results from the first phase were then used to develop a Likert-scale questionnaire (quantitative component) which informed the third phase (qualitative component). The third phase of the research design was semi-structured interviews. The interviews expanded the analyses of data from both initial qualitative and quantitative components.

The reported findings indicated that the learners strongly needed teachers to clearly explain mathematics concepts. The learners required to understand mathematics in order to identify with the subject. The learners explained that if they understand mathematics, they become interested in learning the subject. Mathematics becomes their favourite subject. And if they do not understand, the learners expressed that they withdraw their participation in the classroom. In cases where learners shared incoherent views about how they are at learning mathematics, it was concluded from the analyses of the results that they needed to carefully listen to the teacher, ask for more examples to familiarise themselves with procedures, and then do their level best during assessments to pass the subject in order to align themselves with certain careers in the future.

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CHAPTER 1

INTRODUCTION

1.1 Background to the study

The study seeks to explore learners' identities in mathematics and possible ways in which they can be developed. Drawing on relevant literature, the study examines Grade 8 learning and teaching practice from the perspectives of learners in order to understand how they view themselves in relation to mathematics (Boaler, Wiliam & Zevenbergen, 2000). The study is theoretically framed within the broader social theory of learning by Wenger (1998), and focuses on the analyses of learners' interpretations of their relationships with mathematics.

One aspect of exploring learners' identities in an attempt to increase success in mathematics education has been to compare the subject achievement of different racial, class and gender groups. There are many studies that have been conducted from this perspective. For example, Nasir (2002) concluded that African-American and Latino students score lower on tests of mathematical knowledge than White students. Shih, Pittinsky and Ambady (1999) pointed out that African-American students, who can be stereotyped to be poor in mathematics, underperform as soon as they are aware that they are being tested for their abilities. In South Africa, rural Black female students suffer the most from disadvantages of the education system (Mabokela, 2001, cited in Mophosho, 2013, p. 1). Hence, within this context, South African studies on learner identity tend to focus on political and historical events that have caused inequalities and prejudices towards certain groups in the society (Mophosho, 2013).

South Africa has endured three major curricular reforms in trying to rectify the inequalities and prejudices of the past, and the educational changes have profoundly been historical and political driven (Weber, 2008). South Africans (e.g. politicians, academics) have strived to create a reputable curriculum (Weber, 2008). The ambitions to transform the country's education system were justifiable considering that the curriculum handed down during apartheid was heavy on content, authoritarian, and promoted rote-learning (Jansen, 1999).

In 1997, the government introduced the national curriculum which was referred to as Curriculum 2005 (C2005) (Department of Education (DoE), 1997). The thinking behind C2005 was to look at the need to shift from the traditional aims-and-objectives to outcomes-based education (Stoffels, 2008). In 2002, the government introduced the Revised National Curriculum Statement which retained the outcomes-based foundation from C2005 and looked more into innovative epistemological principles (DoE, 2002). However, learners from better resourced and historically privileged schools continued to benefit the most from the

revised curriculum when compared to learners from historically disadvantaged backgrounds (Christie, 1999), and hence C2005 was abandoned. The current national curriculum document is called the Curriculum and Assessment Policy Statement (CAPS). It intends to ensure that children acquire knowledge and skills in ways that promote local contexts, whilst being sensitive to international imperatives (Department of Basic Education (DBE), 2011).

Within the background of curriculum changes in South Africa, learners' performance in mathematics has remained at the bottom when compared to other school subjects, although there has been some overall improvement in results (DBE, 2014). For schools in rural provinces like Eastern Cape and KwaZulu-Natal, the overall mathematics results remain undisputedly lower when compared to urban provinces like Western Cape and Gauteng (DBE, 2014). This occurrence highlights the challenges around pedagogical principles in the country. That is, the way mathematics content is taught, learned and assessed in the South African system does not adequately provide equal education opportunities for all sections of the population (DoE, 2002).

Furthermore, international studies have revealed that South Africa has not demonstrated strong adaptations to curricular reforms. For example, the country has participated in several international studies such as the Trends in International Mathematics and Science Study (TIMSS), the Monitoring Learning Achievements (MLA) initiative and the Southern Africa Consortium for Monitoring Educational Quality (SACMEQ), but the results from these studies have been unsatisfactory (Chauraya, 2013). Learners from South African schools who participated in the TIMSS 1999 study came last out of 38 countries (Howie, 2012). TIMSS focuses on assessing mathematics and science knowledge and skills based on the school curriculum for grade four and grade eight learners (Reddy, 2005). In other cases, South Africa has low scores in numeracy in the MLA and SACMEQ studies (Reddy, 2005). This is an indication that South Africa needs to commit more towards improving educational quality and accountability particularly in mathematics and the sciences (Reddy, 2005).

To return to learners' identities, researchers (for example O'Brien, Martinez-Pons & Kopala, 1999) concentrated on psychological perspectives such as self-efficacy and self-stereotype of learners as other aspects that can be explored to improve the quality and accountability in mathematics education. Educational psychologists, for example, supported the use of self-efficacy to explain how learners engage themselves in doing mathematics (Boaler *et al.,* 2000). Writers (for example Bandura, 1977; McMillan, 2012) define self-efficacy to be beliefs that motivate individuals to strive to succeed when engaging with mathematical tasks. In another example, it is stereotypical to assume that male students are better achievers in advanced mathematics than their female peers (Mendick, 2005). The notion of self-

stereotyping becomes part of a psychological perspective whereby learners identify themselves in relation to how other individuals of social groups identify them (Shih *et al.,* 1999). Nevertheless, as Aschbacher, Li and Roth (2010) argue, the influence of self-efficacy and self-stereotyping creates negative perceptions from learners about their abilities, career options, and their expected successes, thereby shaping certain mathematical identities and consequential trajectories.

From psychological perspectives, the locus of identity in mathematics education becomes an individual phenomenon (Durkheim, 1956). Identity is viewed to be a fixed and stable ability that each of us possesses (Nasir, 2002). In this sense, the construction of identity is seen largely as the individuals' adaptations or developments intended to fit with the events and situations of life (Erikson, 1968, cited in Boaler *et al.*, 2000, p. 3). Nasir (2002) underlined the fact that identity, even from this perspective, is influenced by the social environment and put forward that psychologists have begun to view identity as a more dynamic construct, fundamentally tied to the social world.

On the other hand, Foucault (1984), cited in Grootenboer *et al.* (2006), challenged the idea of identity formation as being either an individual or a social phenomenon (p. 613). Hall (1992) built on Foucault's theoretical framework and advocated that our identities are continuously shifting to temporarily accommodate what we are subjected to at a particular time and space. Thus, from the post-structural perspective, the process of identity formation is not fixed and is "somewhat unstable" (Grootenboer *et al.*, 2006, p. 613). If identity formation is always changing, the post-structural perspective becomes a theory of discursive practice (Hall, 1996, as cited in Kempe, 2014, p. 36) which does not directly explain "how individuals know and name themselves" (Grootenboer *et al.,* 2006). In other words, identity formation changes rapidly to obscure any predictable learning trajectories. According to Hall (1992), this post-structural viewpoint undermines the same theoretical framework which gave individuals stable anchor in the social world. In this context, Grootenboer and Zevenbergen (2008) argue that researchers are beginning to work across these division lines to validate their investigations on identity. With regard to learning, Lave and Wenger (1991) emphasised the importance of "shifting the analytic focus" (p. 43) from either individuals (as learners) or social phenomenon to emphasise learning as participation in the social world.

Whilst taking into account that researching identity in mathematics education appears to have emerged from psychological and post-structural perspectives, recent researchers (for example Boaler & Greeno, 2000; Gee, 2001; Holland *et al.*, 1998; Lave & Wenger, 1991) believe that significant successes for improving the quality of mathematics are entailed in

framing the concept of identity in socio-cultural perspectives. These perspectives focus more specifically on the interactions between the individual, culture and society. For example, the locus of identity becomes a process of individuals becoming who they are by being able to participate in the practices of a particular group or community (Cobb & Hodge, 2009). The degree of affiliations within the practice supports the process of identity formation that is steered by society with individuals attempting to navigate predetermined passages of knowledge (Grootenboer *et al.*, 2006).

Cobb and Hodge (2009) highlighted difficulties of having many different theoretical perspectives to investigate identity in both mathematics education and other disciplines. The authors encouraged researchers to identify with relevant perspectives that can be tailored to analyse students' identities in mathematics and avoid the politics of which viewpoint is right or not. Boaler (2000a) identified the socio-cultural perspective to be capable of dealing directly with the relations between cognitive changes and social interactions. This theoretical perspective creates bases for understanding the influences that the mathematics classroom community (teachers, learners, and discipline of mathematics) has on students' production of knowledge in different situations, within the social and cultural learning context (Boaler, 2000a). In turn, the socio-cultural perspective allows researchers to analyse identities that learners develop in the classroom that can feed back to inform instructional settings that generate a sense of accountability for both teachers and learners (Cobb & Hodge, 2009). Hence, this study employed a socio-cultural perspective to contextualise the notion of identity and selected Wenger's (1998) broader social theory of learning as a theoretical framework to particularly connect the process of active participation in the practices of social communities and explain the construction of learners' identity in mathematics.

1.2 Statement of the problem

There has been concerns amongst researchers (for example Boaler, 1998, 2000b; Ross, 1998; Handal, 2003) that some mathematics teachers have not abandoned traditional teaching approaches. Learners are expected to understand concepts by being instructed in procedures without connecting them to meanings (Boaler, 1999). By connection, Adler (2005) clarified that Stein *et al.* (2000) meant that task demands do not require learners to connect what they know about mathematical concepts to anything else they know either about the real world or about mathematics (p. 1). It becomes an "instrumental understanding of rules without reasons" where learners may possess the necessary rules, and have ability to use them, without actually comprehending 'why or how' those rules work (Barnes, 2005, p. 45).

Year in and year out, some learners manage to ‘crack the secret code’ of procedures without meanings and pass all their examinations (Zevenbergen, 2000). Given that mathematics is a “strongly hierarchical subject” (Graven, 2015, p. 2), and it is regarded as a difficult subject, politicians and mathematicians outside the schooling system influence the culture of how mathematics should be learned and taught in the classroom (Grootenboer & Jorgensen, 2009). For instance, some mathematicians are still prioritising procedural knowledge and frequently expect learners to be procedurally effective, accurate and flexible in using the rules, definitions, and mathematical syntax (Ross, 1998). They assume that learners will be able to apply those rules and definitions when they eventually advance their careers in mathematics (Lave, 1988). The problem is, however, that some learners instead opt out from advanced mathematics and rather pass it, even with distinctions, and then drop it to pursue other careers which are not necessarily aligned with mathematics (Boaler & Greeno, 2000). This implies that they do not associate or identify with mathematicians; rather they passively receive mathematical knowledge (Boaler, 2002) and assume that mathematics was desired to be passed on paper and be shelved away (Fennema & Sherman, 1976).

Brown, Collins and Duguid (1989) explained that the direct teaching of procedures is similar to attempts at learning a language from the dictionary. The instructing of procedures is similar to instructing on vocabulary by concentrating on the general definitions from the dictionary and constructing sentences out of context of normal use (Brown *et al.*, 1989). With regards to what is learned in mathematics, researchers (e.g., Miller & Gildea, 1987, as cited in Brown *et al.,* 1989, p. 32) argue that these teaching methods, with time, have become generally unsuccessful and almost useless. Rather, researchers advocate that much successful learning of language emanates from listening, talking and reading (Brown *et al.,* 1989). Thus, any power of abstraction of knowledge is “thoroughly situated in the lives of persons and in the culture that makes it possible” (Lave & Wenger, 1991, p. 34) for them to learn.

Brown *et al.* (1989) explored the idea that abstraction of knowledge can progressively be developed by learners and teachers through activities. They argued that knowledge becomes more useful when it is being understood as a tool. People that are working with tools fully appreciate using them when those tools have contributing effects on their view of the world (Brown *et al.,* 1989). Similarly in mathematics education, Brown *et al.* (1989) elaborate that “students can often manipulate algorithms, routines, and definitions they have acquired with apparent competence” (p. 33) in classrooms and yet struggle to apply the same concepts in other relevant domains. Hence, by merely engaging students with activities in classrooms, without linking those activities to practical concepts, students miss

out on ‘relational understanding’ which entails integrating new ideas into existing schemata in order to understand both ‘what to do and why’ (Skemp, 1976; Barnes, 2005).

School mathematics continues to receive unhealthy views from around the world (Grootenboer & Zevenbergen, 2008). In South Africa, an impact of traditional teaching approaches, as inherited by some teachers from the apartheid curriculum, contributes to the negative relationships that many learners are experiencing when learning mathematics. As Graven (2011) indicated, the problem of negative identification with mathematics resonate as early as primary school for many learners, and it includes the terms such as *failure, struggle, stress, nervous, worry, extremely difficult, no confidence* and *hopeless*. So for example, learners who are taught from traditional approaches rely on rote memorisation, and they become hopeless in keeping up with endless rules and procedures. As such, when rules and procedures are isolated from real-life situations, learners struggle to recognise and generalise mathematical concepts (Suh, 2007). In turn, learners perceive mathematics to be a rigid and inflexible school subject where there is no room to negotiate meaning (Boaler, Wiliam & Zevenbergen, 2000). Thus, once problems of identities are understood, learners may be supported to continue studying mathematics whilst they align themselves to advance mathematical careers (Darragh, 2016).

1.3 Purpose of the study

Teachers are potentially blamed for learners’ poor participation in mathematics. As Cooney, Shealy and Arvold (1998) argued, teachers are required to be more grounded in content knowledge. The development of strong content knowledge is significant to improving the quality of education (Grootenboer & Jorgensen, 2009). In addition, Mandeville and Lui (1997) asserted that teachers with high levels of mathematical understandings provide higher quality learning opportunities for students than their peers with limited understandings of mathematics. In South Africa, the Department of Education has mainly utilised training workshops and short courses to develop teachers’ mathematical knowledge and contemporary teaching skills to overcome curricular challenges (Chauraya, 2013). Recent research studies have focused on teacher professional development programs which are designed to impact on knowledge, attitudes and behaviours of teachers in an attempt to improve learning and performance of learners in the classroom (Hull & Saxon, 2008).

Yet given the complexity of mathematics education, researchers may however focus on developing learners by directly exploring their engagements in learning for success in the classroom. Putman and Borko (2000) suggested that “how a person learns a particular set of knowledge and skills, and the situation in which a person learns, become a fundamental part

of what is learned" (p. 243). Boaler, Wiliam and Zevenbergen (2000) explained that students learn more than just mathematical knowledge and skills in the mathematics classroom. Boaler (2002) advocated that researchers may begin to explore the relationships between knowledge, practice and identity to influence students' development towards learning mathematics for success in the classroom. Grootenboer and Zevenbergen (2008) looked specifically at *identity* to be a useful conceptual tool to "understand mathematical learning because it includes the broader context of the learning environment, all the dimensions of learners' selves that they bring to the classroom" (p. 243). Within these explanations, the purpose of this study was to explore learners' identity in mathematics. It was critical to focus on examining learners' experiences on identification from local and international studies that could practically contribute to enhancing research studies for South Africa. If not, Ruffell, Mason and Allen (1998) recommend that research studies should at least point out effective ways of probing and developing instruments which would be easy for teachers to use as tools towards their own enquires into informing their teaching of mathematics.

'Learners' identities in mathematics' in this study refers to views, beliefs and interpretations held by the Grade 8 learners about themselves and by others when participating in the processes of learning and teaching of mathematics. In defining learner identity, the study rejected the view that mathematics learners are born with special genes which drive them to succeed in doing the subject (Devlin, 2000b, as cited in Anderson, 2007, p. 11). This implies that learner identity is not fixed for a few individuals; rather it can be developed through engaging learners with mathematics. As such, learner identity is presented as relationships between emotional and cognitive reactions that shift from time to time whenever mathematics is made accessible for learners through active participatory pedagogy which encourages exploration, negotiation and ownership of knowledge (Solomon, 2007).

In the literature review, Wenger's (1998) three modes of belonging were discussed to make sense of the formation of identity and learning in mathematics, and these are as follows: engagement, imagination and alignment. In discussing engagement, the study looked at cognitive and behavioural reactions that propel learners to participate or not participate in the mathematics classroom. Also, the study discussed imagination and alignment as the motivating factors that learners develop to connect to the broader world of mathematical knowledge and learning inside and outside the classroom. The two modes (imagination and alignment) are not observable, but according to Anderson (2007), the affective consequences give acceptance to the goals of schooling through the sense of belonging and compliance. Therefore this study intended to explore such dimensions, if they emerge from the current research, and further analyse them for their appropriateness in the South African context.

To give the present research a focus, researchers (for example Darragh, 2013; Newstead, 1998) asserted that learners in junior secondary school are at the critical level for the development of positive identities and other favourable affective factors toward mathematics. According to Cobb and Hodge (2009), learners' persistence, interest in, and motivation to learn mathematics form part of positive identities. It has been established from a socio-cultural perspective that identities of learners change throughout a schooling progression depending on their classrooms' experiences. Accordingly, this study sought to examine learners' views of doing mathematics from when they were in primary school to junior secondary school, and to further project to their future aspirations. If there were changes in their experiences, the study required to understand circumstances or reasons that have caused those changes in order to support progressive learning trajectories. The challenge is that once learners have developed negative perceptions about mathematics, it becomes difficult to change them and somehow these perceptions may persist into adult life, with far-reaching consequences (Newstead, 1998). Therefore, additionally, the study investigated how learners can be supported to develop and improve identity which will prepare them to fully participate in the future mathematical education and careers.

1.4 Research questions

The following research questions guided the study:

(a) What are the factors of learners' identities that emerge from Grade 8 mathematics classrooms?

(b) What caused the changes in learners' identities from when they were younger to now if there have been any changes?

(c) How can learners be supported to develop identities in mathematics?

1.5 Rationale

As part of the Bachelor of Education with Honours degree, students are introduced to a research project. In my case, I investigated junior secondary school learners' attitudes towards mathematics. The research questions sought to examine what attitudes the learners have and explored the influences these attitudes have on learners' subject choices. As the conceptual framework, I employed a 'tripartite' view of attitudes which incorporated cognitive, affective and behavioural components. This conceptual framework was recognised by Barmby, Bolden and Raine (2014) to have encompassed broader views of attitudes in the mathematics education literature. Sfard and Prusak (2005) argued that learners' attitudes towards mathematics alongside beliefs and conceptions form part of their identity in

mathematics. Thus, when the opportunity was presented, it was reasonable to want to extend my understanding of emotional and cognitive factors of mathematics and embark on investigating identities of learners in mathematics.

In addition, it is hoped that the present study will add value to research on identity by using a mixed methods approach. The study came at a time when researchers, for example Barmby and Bolden (2014), looked to utilise the strength of both qualitative and quantitative features to research emotional reactions of participants in mathematics. The combination of qualitative and quantitative methods moved beyond the matter of having more than one type of data collection instrument, but rather, for instance, one method being used to develop the instrument for the next stage of the research. For example, Barmby and Bolden (2014) firstly would collect views of participants from open questions and then use statements from participants to formulate Likert-scale questionnaire items. In support of the approach and to elaborate on the example, literature shows that the use of open questions dates back many years in the history of researching emotional reactions of participants (Aiken, 1970). The purpose of open-ended questioning has been to encourage participants to freely express their individual views about the focal object without leads from the researcher other than the dimensions of appraisal such as 'What do you think…'and 'How are you at…' (Barmby & Bolden, 2014). However, many researchers resort to relegating the use of open questions to pilot studies because of their complexity for being utilised in quantitative analyses (Agheyisi & Fishman, 1970). The crux of the matter is that the technique of converting statements from open-ended questions to Likert-scale items has been welcomed for studying many other groups for their emotional reactions or for other topics that can be done "by changing the focus of the initial open statements" (Barmby & Bolden, 2014, p. 103). Indeed, this technique gives a mixed methods approach a very powerful component to increase the rigour of research (Creswell, 2012). Hence, this study will also explore the possibilities of using mixed methods approaches to explore learners' identities in mathematics.

1.6 Summary

This chapter has provided details of the background to the study, the problem statement, and the purpose of researching learners' identities in mathematics. This chapter has further discussed the rationale for embarking on this study. In the rationale statement, it was highlighted that the study intends to utilise mixed methods research which will be further discussed in Chapter 3. However, the next chapter (Chapter 2) discusses the theoretical framework alongside the literature review of the study. These two sections are presented in one chapter because they are interconnected and inform each other.

CHAPTER 2

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

In this chapter the study begins by providing a general definition of identity in mathematics. A general definition encapsulates what is common from various definitions of identity in the literature (Beijaard, Meijer & Verloop, 2004). Secondly, Gee's (2001), Wenger's (1998), and Sfard and Prusak's (2005) perspectives on identity are discussed accordingly to illuminate operational definitions used in this study. Furthermore, the integrated perspectives provide necessary backgrounds to support the study's theoretical framework. Going forward, Wenger's (1998) social theory of learning was selected as a broader framework that frames the study. Lastly, the key identity components (learning, meaning, community and practice) are elaborated on within the social theory of learning to inform the research questions, and further used to review central themes (the interacting learner, lack of meaning, and monotony) from Boaler's (2000b) study which focuses on the construction of learner identity.

2.2 Definition of identity in mathematics

Sfard and Prusak (2005) investigated studies which defined identity in a more operational manner. The authors intended to find a more explicit definition of identity in mathematics whilst preserving an appropriate use of language from the literature. On the surface, there was an impression that identity in mathematics emerged as "natural givens and biological determinants" (Sfard & Prusak, 2005, p. 15) for certain individuals. Stated in simple terms, some learners relate more with mathematics because the subject is embodied in their makeup or genes (Anderson, 2007). This suggests that learners who are performing poorly in mathematics "have no control" (Anderson, 2007, p. 10) towards improving their understanding and knowledge of the subject. Researchers (for example Devlin, 2000b, as cited in Anderson, 2007, p. 11; Gee, 2001; Lave & Wenger, 1991) refuted this point of view.

It follows rather that every learner has the ability to learn and be taught mathematics. Devlin (2000b), cited in Anderson (2007), asserted that everyone has the mathematics gene (p. 11). Hence, identity in mathematics is not fixed for a few lucky individuals (Johnston, 2012). Johnston (2012) argued that "identity is under construction and is continually forming and reforming" (p. 12) in mathematics learners. This argument is in line with Wenger (1998) who viewed identity as a dynamic aspect of learning which is created and re-created by learners' participation in the classroom. The learners' participation is recognised at a given time, it can change from context to context, and it can be ambiguous or unstable (Gee, 2001). In specific

terms, learners use their past and present experiences to aspire to future participations in mathematics (Anderson, 2007).

In order to fully participate in mathematics, learners need to firstly become members of a mathematical community (Lave, 1993). Through interaction with others (Anderson, 2007), members of a mathematical community transform their lives from who they are to what they can do (Wenger, 1998). In this sense, for example, mathematics learners begin to talk about how learning can change who they are within their social and cultural spaces (Wenger, 1998). Thus, mathematics learners become aware of how they view themselves in relation to how they are viewed by others (Lave, 1993). However, some learners are recognised by other members in a mathematical community (e.g. teachers, parents and peers) as being more central to the practice and others situated on the periphery (Wenger, 1998).

2.3 Social learning theories: Identity perspectives

To explain different positions that members of a mathematical community find themselves in, the study highlights three perspectives that provide different but complementary perspectives for defining and viewing identities. Given the multi-faceted construct of this area, researchers (for example Chauraya, 2013; Kempe, 2014; Lerseth, 2013) have approached identity formation by contrasting and comparing a variety of perspectives to set up integrated theoretical frameworks for their studies. Accordingly, this study considered three perspectives that are offered by Gee (2001), Wenger (1998), and Sfard and Prusak (2005) in their social learning theories.

2.3.1 The Gee (2001) perspective

Gee (2001) described four ways of viewing identity. These are: Nature-identity, Institutional-identity, Discourse-identity, and Affinity-identity. See the synopsis of these four ways of viewing identity and their processes of construction in Table 2.1 below. When these views are understood within institutional and socio-cultural contexts, members of a mathematical community can comprehend why some learners are in different learning positions. In addition, members can learn how to act or interact with each other in order to fully participate in mathematics.

Table 2.1: Four ways of viewing identity as categorised and described by Gee (2001).

Category	Process of construction
Nature-identity	A natural perspective that may be due to genes or neurological state.
Institutional-identity	A position authorized by authorities within institutions.
Discourse-identity	An individual identity which is influenced by dialogues or voices from a community.
Affinity-identity	An experience shared by a group of people in a specific practice.

The natural perspective (Nature-identity) describes who we are from what nature gave us at birth such as gender and skin colour. Learning outcomes which depend on how we act or interact in a mathematical community do not have direct relationships with what we were born into. Rather, institutional and socio-cultural spaces produce, maintain and reinforce characteristics of a natural perspective by encouraging (or discouraging) others from participating in a mathematical community. In Gee's (2001) terms, natural identities can only become identities because they are recognised, by an individual or others, to constitute anything meaningful in creating a certain "kind of person" (p. 102). Thus, the work of schools, teachers, teacher educators, and learners can offer support to individuals who are disadvantaged by a natural perspective to develop positive learners' identity in mathematics.

The second way of viewing identity is Institutional-identity. This identity looks at positions assumed by an individual within an institution. For example, learners who are participating in this research have to recognise that they are in a Grade 8 class, and that they are mathematics learners as categorised by the schooling system. These learners are expected to accept roles and responsibilities associated with being Grade 8 mathematics learners. Gee (2001) explained that the institutional view positions people on a continuum of how actively or passively they are in fulfilling their roles or duties. Gee (2001) used the example of prisoners. The author stated that prisoners are often forced to carry out certain activities, and therefore, they might be passive in their participations.

The third way of looking at identity is from the discursive position (Discourse-identity). 'Rational individuals' tend to categorise individuals as certain kinds of people (Gee, 2001). By 'rational', this implies that these individuals treat, talk about, and interact with people to create and sustain the kinds of people they want to see in the society. In some sense, those people get to own the kind of treatment they receive from a discursive position. In the classroom, for example, some learners are said to be 'high achievers' in mathematics

because of their consecutive performances during assessments. As such, the positions of those learners gain traction from stories as narrated by the teachers or other learners. Such learners become cognisant of their status and begin to attend to mathematical activities with a resilient attitude to maintain perceived positions. As Gee (2001) argues, Discourse-identities provide the labelled individuals with opportunities to nurture those characteristics or opt out.

The last way of looking at identity according to Gee (2001) is Affinity-identity. Gee (2001) described an affinity group as people who participate in specific practices that provide each of the group's members the requisite experiences. The author argued that the source of power for Affinity-identity is not nature or institutions, or even other people's discourses and dialogues alone, but an affinity group. Thus, the Affinity-identity perspective focuses on how individuals build their relationships with others in joint activities (Gee, 2001). Members of the affinity group sustain their allegiance to uphold the sense of belonging and that of social affiliations. In fact, Gee (2001) uses the term 'affinity groups' interchangeably with 'communities of practice'. More details on communities of practice will be provided later on. What follows below is the discussion of Wenger's (1998) perspective.

2.3.2 The Wenger (1998) perspective

A description of Wenger's (1998) social theory of learning is provided here. There are three main reasons for this description. Firstly, the discussion gives an account of where the social theory of learning is located. Secondly, the social theory permits the systematic descriptions of identity by connecting them to aspects of learning, meaning, community and practice. Thirdly, in the next segment, Wenger's (1998) social theory of learning will inform the literature review of this study in order to further explain central concepts such as the development of identity in relation to the learning of mathematics in the classroom.

Wenger (1998) explained the 'intellectual context' (p.11) of his social theory of learning by locating it at the intersection of two axes of intellectual traditions, as illustrated in Figure 2.1 below. In the tradition of social theory, the vertical axis has two ends that are described as 'theories of social structure' at the top, and 'theories of situated experience' at the bottom. Theories of social structures put emphasis on institutions, cultural systems, discourses, and history whilst theories of situated experience give primacy to agency of individual actors and their intentions. The social view of learning is thus placed in the middle. In Wenger's (1998) theory, learning takes place through our individual engagement in actions and interactions, but embeds this engagement in culture and history. In turn, learning reproduces and transforms the social structure in which it takes place (Wenger, 1998).

Wenger (1998) also placed a horizontal axis and described each end as 'theories of social practice' on the left-hand side and 'theories of identity' on the right-hand side. Theories of social practice address the production and reproduction of ways of engaging with the world. On the other hand, theories of identity focus on the issues of gender, class, ethnicity, age, and other forms of categorisation. Within this axis, Wenger (1998) placed the social view of learning in the middle again.

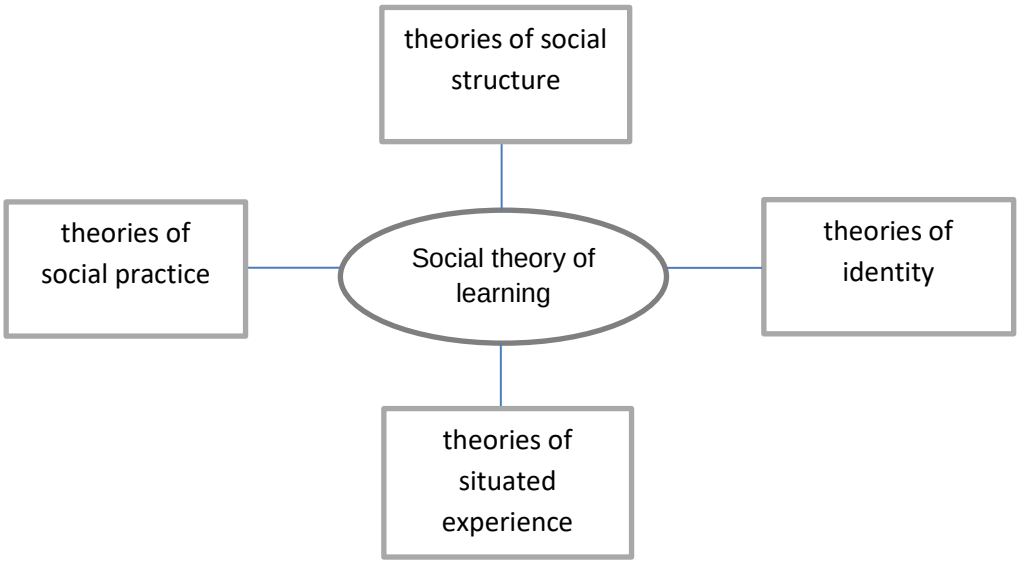


Figure 2.1: Two main axes of relevant traditions (Wenger, 1998, p. 12)

Wenger (1998) proceeded to articulate that his theory has four interconnected components of identity that are necessary to characterise the social view of learning. The interconnected components are culminations of conceptions attained from the intellectual traditions presented around Wenger's (1998) social theory of learning. These components are shown in Figure 2.2 below, and they are: learning, meaning, community and practice. Wenger (1998) argues that these four components are "interconnected and mutually defined" (p. 5), and in fact advocates that any of the four peripheral components can be switched with 'identity' and the figure would still make sense. Each component of identity is discussed below.

Community: Identity as belonging

Wenger's (1998) described three modes of belonging (engagement, imagination and alignment) to a community. Anderson (2007) refers to these modes of belonging as 'faces' of identity. The phenomenon of modes of belonging is significant to studies that have employed Wenger's (1998) social theory of learning. Chauraya (2013) has used the modes of belonging as the analytical framework for studying identity. However in this section, the

modes of belonging are discussed in relation to how they influence the learning of mathematics. Accordingly, each mode of belonging is discussed starting with engagement.

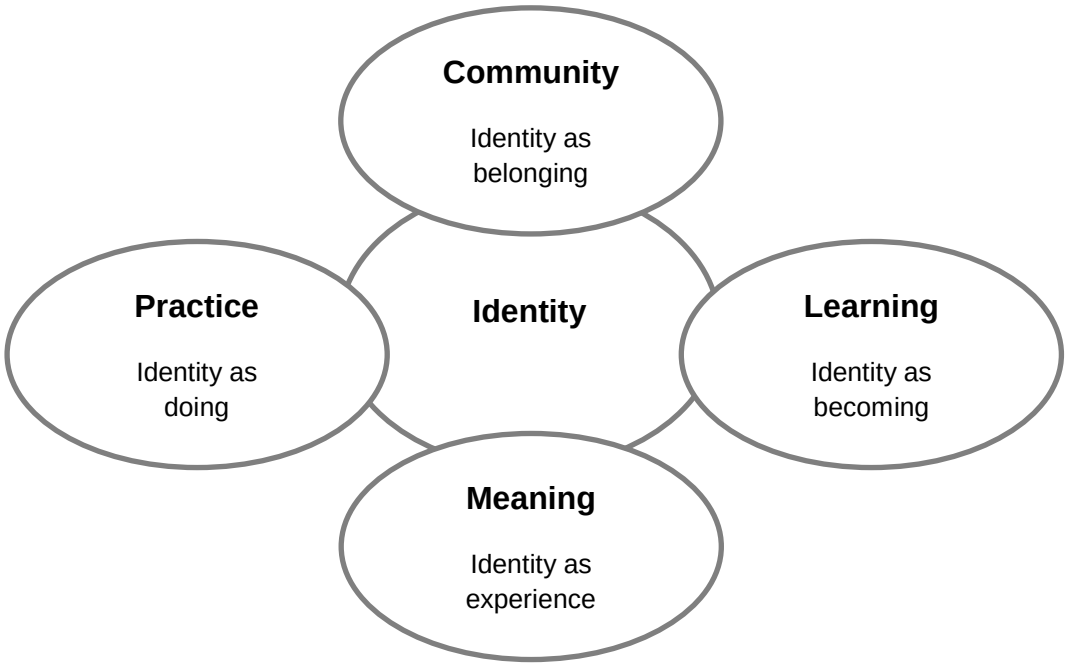


Figure 2.2: Identity components of Wenger's (1998) social theory of learning (p. 5)

From a constructivist view, engagement meant that learners are continuously adapting to processes of procedures, mathematical concepts and skills that are offered to them in classrooms (Hatano, 1996). Constructivists propose that learners are able to actively organise their different ideas into their own schema, selecting, adapting and reorganising information to develop knowledge (Boaler, 2002). Parallel to that, teachers are required to facilitate or mediate learning by sharing their experiences with learners to encourage new construction of knowledge (Hatano, 1996). However, social perspectives on learning extend this notion of developing knowledge, from an individual adaptation process to a process that is distributed among learners and activities and systems within their environment (Boaler, 2002).

Wenger (1998) described engagement as an active involvement of individuals in mutual processes of negotiation of meaning. The author alluded to the fact that engagement can take place at a certain time and space. An intense space for learners to negotiate meaning is in mathematics classrooms. Learners get to interact with their peers in the classroom, and with the involvement of teachers and parents, they discover identities about themselves as mathematics learners (Anderson, 2007). The negotiation of meaning allows more learners to appreciate their capabilities of "doing mathematics" (Ross, 1998; Boaler, 2000b). Learners

come to see themselves moving towards the centre of the mathematics learning community (Lave & Wenger, 1991). In this regard, for example, learners stop celebrating ultimate single answers to mathematical exercises (Anderson, 2007) and place more emphasis on the "authentic access to both the participative and the reificative aspects" (Wenger, 1998, p. 184) of learning mathematics. Details of 'the negotiation of meaning' aspects will be provided below when discussing 'identity as negotiated experience'.

What happens when learners do not engage meaningfully in learning of mathematics? This implies that learners are denied access to knowledge through social interaction. Boaler (2000b) pointed out that classrooms can appear alien or esoteric to some learners. As such, learners may not identify with classroom environments and "may come to see themselves as only marginally part of the mathematics community" (Anderson, 2007, p. 8). In this case, Boaler and Greeno (2000) explained that learners can be offered opportunities to connect with mathematics on a personal level in order for them to feel that their explanations and contributions are accepted in classrooms' discussions. This will mean that learners are being recognised as members of the community and begin to see themselves as competent at learning mathematics (Boaler & Greeno, 2000).

A second mode of belonging is imagination. To describe imagination, Wenger (1998) provided an analogy of two stonecutters who were asked what they were doing. One responded: "I am cutting this stone in a perfectly square shape." The other responded: "I am building a cathedral." The second stonecutter connected himself to a broader community of builders (Nasir, 2002). In other words, the second stonecutter related his engagement to a broader imaginary scheme of things. Nonetheless, the first stonecutter was not wrong in giving an exact account of what he was doing (Wenger, 1998). To return to learning, Anderson (2007) asserted that high school learners are mostly aware of their place in the world. As such, learners respond with some in-depth considerations when they take into account how mathematics fits in with other activities in their present and in their future (Sfard & Prusak, 2005). Hence, learners begin to affiliate and engage more with classrooms activities whilst, on the other hand, focusing their attention on how these activities can be useful in their everyday life (Nasir, 2002).

Anderson (2007) confirms that the prospect of taking mathematics seriously at high school occurs more when individuals have to apply mathematical concepts and skills in their everyday life. For example, learners find themselves being aware of having to spend money when they are purchasing groceries (Nasir, 2002) or having to save money from their allowances. In education, learners imagine future access to universities in disciplines such as science studies which require certain high grades in mathematics (Anderson, 2007).

Moreover, some learners take mathematics in high school to align themselves to future jobs opportunities (Sfard & Prusack, 2005). Wenger (1998) asserted that learners locate themselves in the world and in history through imagination.

According to Wenger (1998), imagination is a mode of belonging that always involves the social world which then expands the scope of reality and identity. Conversely, imagination can also disconnect individuals from the broader community. That is, the broader context may contribute negatively to some individuals within the society (Gee, 2001). For example, there are learners who cannot associate themselves with certain broad reasons that are provided in society for studying mathematics (Anderson, 2007). For instance, not every learner wants to enrol for science studies despite being considered as an important area by the society. As such, and without taking into account the everyday necessity for mathematics, the imagination and engagement of those learners linger on the periphery of the community of practice (Lave & Wenger, 1991).

The third mode of belonging is alignment. Nasir (2002) described alignment as "how actions within that community come to be aligned toward a broader common purpose" (p. 219). This mode demands learners to channel their energies within their institutional boundaries (Wenger, 1998). In the process of alignment, the mathematics teacher can expect learners to adopt a certain position in the school to connect to broader practices (Gee, 2001). For example, my mathematics teacher would hardly finish his lesson without uttering that by "being here in the mathematics class, you are a cut above the rest and you must go home and practice mathematical procedures because you are destined to be future scientists." Teachers believed, back then, that the best way for pupils to learn mathematics would be to gain multiple opportunities to practice methods, thus re-forcing certain behaviours (Boaler, 2002). The teacher was connecting our participation to an affinity group of scientists we knew very little about (Gee, 2001), and according to Anderson (2007), teachers can take an active role in keeping students informed of mathematics requirements for careers and university entrance. Wenger (1998) affirms that "the process of alignment bridges time and space to form broader enterprises" (p. 179).

In the current South African education system, learners have a choice between mathematics and mathematical literacy when they advance their schooling to the senior secondary stage (Department of Education, 2005). Malahlela (2015) noted that mathematics offers learners with more elite post-school education and employment opportunities. As such, some schools in the country set high standards for junior secondary learners as a requirement for them to proceed with mathematics in the Further Education and Training phase (Bowie & Frith, 2006). That is why some grade 8 learners concentrate more when learning mathematics in

order to align themselves with certain career choices (Anderson, 2007). As a result, learners who intend to pursue post-secondary educational careers with mathematics as a requisite "direct their energy towards" (Anderson, 2007, p. 10) learning and passing the subject than learners who cannot imagine the need for mathematics in their future endeavours. Thus high school learners strive to comply with the requirements set by teachers, school districts, universities and so forth (Wenger, 1998).

Wenger (1998) also flagged the negative side of this alignment mode of belonging. The author observed that alignment within the system can be disempowering and abusive. For example, mathematics learners in high school may be expected to attend extra lessons after school or on weekends or holidays (Barnes, 2004). The obvious threat that learners identify with is that they will fail if they do not accept extra support from teachers (Barnes, 2004). The source of this power is not affinity groups or communities of practice, but the institutional identity (Gee, 2001). The process through which this power works is authoritarian factors based on traditions and rules (Gee, 2001). When the source of power is the institution, learners can choose to "adhere to the rules of the game" (Sfard & Prusak, 2005, p. 19) and produce evidence of their work to impress teachers rather than to strive towards substantial learning.

Meaning: Identity as negotiated experience

Identity as *negotiated experience* can be reconciled with the earlier discussions of how learners can negotiate meaning in the classroom. Meaning is referred to as our ability to experience the world as meaningful (Wenger, 1998). This requires that we negotiate meaning for our life. According to Wenger (1998), the negotiation of meaning entails talking, thinking, acting and solving problems within the certain practice. More often than not, we may do and say things that have been said and done in the past, "and yet we produce again a new situation, an impression, an experience: we produce meanings that extend, redirect, dismiss, reinterpret, modify or confirm the histories of meanings of which they are part" (Wenger, 1998, p. 52 – 53). As Wenger (1998) elaborates, the process of negotiation of meaning becomes more prominent in practice when learners are involved in mathematical activities that they 'care about' or when they are presented with problems without the world imposing one way of finding solutions. Hence, the process of negotiating, co-constructing and modifying of meanings becomes another form of identification (Wenger, 1998).

Wenger (1998) defined this form of identification as a product of the way we live to experience the world. How much of learners' lived experiences are taken into account in the negotiations of 'rules and procedures' that are used in mathematics classrooms? Ball (1993) responded firmly to this question and asserted that children learn about subjects (e.g.,

music, geography, history, and so forth) but those subjects are separate from them. Part of the solution to this assertion requires “connected teaching” strategies which attempts to link lived experiences and conceptual understanding instead of authoritative texts or authoritative teaching (Ball, 1993). Esmonde (2009) refers to connected teaching to be a shared process between learners and teachers in solving mathematical problems to ensure connected ‘knowing’ and making mathematics more equitably accessible. This promotes self-images whereby learners begin to talk about themselves and about each other when engaging through negotiations in specific communities (Wenger, 1998). As such, narratives of learners give certain meanings to form identities (Wenger, 1998).

Practice: Identity as doing

Identity as *doing* entails both lived experience and a display of competence within familiar territory of individuals (Wenger, 1998). That is, when we engage with other members, we must recognise our areas of competence whilst allowing others to recognise us as being competent (Wenger, 1998). Research on learning within a domain of fostering competence has focused on mathematical explorations as a significant classroom practice that can encourage learners to discuss how to solve new or unfamiliar problems (Goos, 2004; Zhu & Simon, 1987). As Wenger (1998) argues, we know who we are by being able to synthesise what is unfamiliar with what is familiar in order to understand the world. Learners with the identity as *doing* component are confident enough to trace back on their work from known to unknown.

According to Zhu and Simon (1987), learning by exploration is nearly synonymous to learning by doing. During explorations, for instance, learners can discover patterns and test them to arrive at a valid generalisation (Flores, 2010). For Zhu and Simon (1987), prerequisite knowledge becomes a first step for learners to discover patterns. For example, when teaching learners how to solve quadratic equations, even if learners are not familiar with the concept of quadratic equations, they must be clear about what it means to solve an equation. In junior secondary, learners can be familiar with solving linear equations. Also, the learners must know the concept of multiplying numbers or squaring numbers. For the next interactive steps between the teacher and the learners in the mathematics classroom, Goos (2004) looked at presumptions made in the Zone of Proximal Development as a framework for teaching processes towards getting learners to generalise mathematical concepts. For instance, in each step, learners can be asked to check their answers (if necessary, for instance, they can use calculators) or the teacher can provide feedback or scaffold essential information to move learning forward. At the same time, learners can be reminded about the activity goals.

For Wenger (1998), identity becomes a mutual engagement where we develop certain expectations about how to interact and work together. As part of working together on the shared activity, researchers (for example Barnes, 2000; Flores, 2010) recommended collaborative learning as one strategy that can enhance the learning of mathematics. Grootenboer *et al.* (2009) suggested that learners should not feel like they are working in isolation. Learners can be asked to explain their solutions to each other. It emerged in Boaler (2000b) that some learners prefer to ask other learners for help. Collaborative learning can be utilised as the supporting structure for learner-centred engagement in classrooms (Brodie, 2007). That is, learners can be allowed to share and discuss mathematical activities. When learners have shared and understood a mathematical concept, each learner tends to follow his or her path towards finding similar or different solutions to those of others (Kempe, 2014). As such, learners are able to justify and explain their work to promote mathematical reasoning (Brodie, 2009). Hence, collaborating is valued in social and cultural communities of learning mathematics (Burton, 1999a). At the end of exploration, the teacher can start engaging learners with appropriate terminology and formalising mathematical ideas.

Learning: Identity as becoming

It has been noted that identity entails aspects of lived experience by considering what we have learned in our past. As such, our past experiences shape knowledge and skills that we have accumulated in a process of becoming certain individuals. Certain individuals are characterised by what they know and do not know about their mathematical communities. Therefore, the construction of present identity is an on-going process of becoming what we are inspired to achieve in the future (Nasir, 2002; Stentoft & Valero, 2009). In Wenger's (1998) terms, the construction of identity is defined "with respect to the interaction of multiple convergent and divergent trajectories" (p. 154).

Given a range of factors that are influencing the learning of mathematics in the classroom, identity as *becoming* tends to be continuously changing experiences of what matters and does not matter in the lives of learners (Boaler, 2002). The modern world has different ways of shaping and positioning (or locating) people in communities of practice (Lave, 1993). For example, there are children that are suffering from undiagnosed health conditions. To take ADHD for example, Gee (2001) categorised children with such conditions to have fixed natural identities because these conditions constitute the kind of persons they are. Gee (2001) put forward that natural identities always gain power or disempowerment through the work of institutions, discourse, or affinity groups. In this case, such health conditions may have hidden negative effects towards children's learning abilities if institutions or affinity

groups members fail to attend to them. These children may struggle to negotiate their natural identities for future learning projections (Wenger, 1998) if they do not receive some form of mediation from societies. Consequently, learners may never end with full membership in the mathematical community of practice (Wenger, 1998).

Gee (2001) categorised the concepts of lived experiences of students that are influenced by the availability of learning resources within the learning institutions as an institutional identity. Learners are positioned within communities of practice according to institutional means. For example, public schools that are 'poor' – as categorised by the National Department of Education in terms of the lack of infrastructure factors and the poverty of communities around them – are more likely to generate and regenerate individuals that remain on the periphery of communities of practice. This means that some individuals are trapped within the gloomy cycles of social location (Bourdieu, 1986; Van der Berg *et al.*, 2011, as cited in Spaull & Kotze, 2015, p. 26), and those individuals have no adequate learning means to envisage a prosperous future (Holland *et al.,* 1998). Wenger (1998) described this exemplary phenomenon as a 'learning peripheral trajectories' where individuals are provided with mere access to mathematical communities which however "never lead to full participation" (p. 154). Thus, learning obstacles – for example, a "hole on the roof" of the classroom due to dilapidated school buildings, undiagnosed health conditions, or language barriers – can limit individuals from becoming certain learners of mathematics (Skovsmose, 2005, p. 5).

2.3.3 The Sfard and Prusak (2005) perspective

Sfard and Prusak (2005) used 'identity as narrative' as another perspective to describe and investigate learning within social and cultural contexts. Many contemporary researchers (for example Aschbacher, Li & Roth, 2010; Bishop, 2012; Dyer & Keller-Cohen, 2000; Holmes, 2005; Sfard & Prusak, 2005; Varelas, Martin & Kane, 2012) define 'identity as narrative' to be a collections of stories that are narrated by us about ourselves and about others. The benefits of viewing identities through storytelling fit into the motivational notion of learning by interacting with others in communities of practice (Lave, 1993). As Wenger (1998) argues, we learn by 'doing' whilst lived stories of old-timers encourage newcomers to move from the peripheral position to full participation.

Holmes (2005) stated that stories are complex discursive formations with enabling factors for constructing identities of individuals in relation to others within communities of practice. According to Foucault (1970),

> whenever one can describe, between a number of statements, such a system of dispersion, whenever, between objects, types of statement, concepts, or thematic choices, one can define a regularity (an order, correlations, positions and functionings, transformations), we will say, for the sake of convenience, that, we are dealing with discursive formations (p. 38).

In this post-structural context, identity refers to the combined individual voices to form a stronger voice of a community (Sfard & Prusak, 2005). The contributing factors for unifying individual's voices come into play in classrooms and outside schools when learners interact with each other in one-on-one, face-to-face interactions, after school conversations, and recently on social media type of situations (Holmes, 2005). This includes family participation in these 'informal narratives'. Thus, the collection of stories creates or changes identities of individuals to adopt a certain "position and status" about the nature of learning mathematics (Varelas *et al.,* 2012, p. 324). For example, changes in position and status can motivate learners who are perceived by their communities or by themselves as being 'pretty clever' to thoroughly engage with mathematical ideas and activities to prove being worthy of being characterised as being pretty clever in doing the subject (Forster, 2000). Holland *et al.* (1998) state that "people tell others who they are, but even more importantly, they tell themselves and then try to act as though they are who they say they are" (p. 3). Sfard and Prusak (2005) highlight that informal conversations have reifying qualities if they come with adverbs such as 'always' and 'usual'. Therefore, in turn, such positive conversations boost learners' confidence in engaging with mathematical contents which grows into performances that are endorsed by learners or institutions (Forster, 2000).

Furthermore, learners need to be oriented through 'formal narratives' about the subject in order for them to gain knowledgeable skills (Holmes, 2005). A schooling system has the potential of constructing individuals' social identities from institutional identities (Gioia & Thomas, 1996). In the classroom, the community of practice includes all learners, but is usually dominated by the teacher (Grootenboer & Zevenbergen, 2008). As such, the roles of teachers become important in sharing their life stories. According to Holmes (2005), sharing life stories can encourage learners to develop an interest in learning mathematics once they understand how the subject has transformed the teachers' life. Sharing life stories also lessens the authoritative voice which closes down avenues of social discussions (Bakhtin, 1981, cited in Kempe, 2014, p. 28). Drawing parallels with other communities, researchers (for example Cain, 1991; Holland *et al.,* 1998; Lave, 1993; Lave & Wenger, 1991) consider the characteristics of Alcoholics Anonymous (AA) as a learning environment. That is, through talk and sharing of personal stories or history, newcomers learn ways of becoming sober and they are gradually constructing their own stories to share when they ultimately become old-timers in the AA community (Cain, 1991). Sfard and Prusak (2005) described

AA stories to be significant stories because they often validate “one’s memberships in, or exclusions from, various communities” (p. 17).

Holland *et al.* (1998) conceptualised the ‘figured world’ as the “socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others” (p. 52). In the ‘figured world’ of learning, the capabilities of learners to pass mathematics and grades are recognised and tested by teachers and schooling systems. In Rubin’s (2007) study, teachers were adamant in their collective voices that the inabilities of students to receive passing grades are caused by their own incompetence. In some instances, the message of blaming learners can be interpreted to have been endorsed in an institutional philosophy (Holmes, 2005). In defence, learners (and parents) explain their failures by blaming teachers. Forster (2000) believes that teachers have a responsibility to take more blame for students’ failure instead of uttering types of statements which are discursive practices that distance students from constituting mathematical identity.

Sfard and Prusak (2005) advocated two significant subsets of narratives which represent analytical perspective of developing identities. There are ‘actual identities’ and ‘designated identities’. Actual identities refer to the understanding of us from stories which are narrated by ourselves and by others in the present tense (Sfard & Prusak, 2005). Stories that are told to us now have a potential to change our current views about ourselves, and if our views are not influenced by current views, people expect us to become acceptable to who we are in the future. Thus, designated identities are based on the commitments and targets we have set for ourselves to become in the future (Sfard & Prusak, 2005). Our means of setting targets arise from labels and descriptions we obtain in actual identities in the form of grading in schools or certificates we achieve from institutions (Nasir, 2002). Institutional identities become our window of viewing and weighing designated identities (Sfard & Prusak, 2005). Hence, if authors of actual identities are ourselves and are addressed to ourselves, the actual identities are believed to be likely to have the most immediate impact on our future actions (Sfard & Prusak, 2005).

2.4 Integrated perspectives informing the development of learner identity

The deliberated three complementary perspectives on identity from within social theories illuminate the complexity of dealing with learners’ interpretations of their relationships with mathematics for this study. However, the integrated perspectives provide operational definitions and particular ways of viewing identity within the socio-cultural context of learning mathematics. Identity labels from the integrated perspectives can be used to stereotype,

privilege, disempower, empower, or marginalise learners. During labelling, learners can be categorised as being effective or ineffective, proficient or non-proficient, or successful or unsuccessful at learning mathematics (Lerseth, 2013).

Gee's (2001) four ways of viewing identity set up comprehensive but unambiguous categorises to be considered in exploring what it means to be a mathematics learner. According to Lerseth (2013), Gee's (2001) perspective describes 'who a mathematics learner is'. Wenger's (1998) perspective describes identity from 'what a mathematics learner does'. Wenger's (1998) perspective gives further details on an institutional identity. It postulates how learners can negotiate meaning in order to belong to a community. It further theorises what learners can do in the classroom to become certain individuals that are more central in the practice. The aspects of 'identity as narrative' (Sfard & Prusak, 2005), and the Discursive-identity (Gee, 2001) complimented the aspects of 'identity as negotiated experience' (Wenger, 1998) by contending 'what mathematics communities say' or 'how they interact and act' to empower (or disempower) certain individuals. Taking all these contributions that formed the integrated perspectives into account, this study focused on using Wenger's (1998) broader social theory of learning as a theoretical framework for two main purposes when exploring learners' identities in mathematics.

For the first purpose, the concepts of identity as *becoming* which entail lived experiences of mathematical community members became a descriptive structure in formulating the research questions of this study. The first research question seeks to identify factors of identities from learners' lived or negotiated experiences. The second research question is intended to compare learners' identities when they were younger to now. The second question becomes the confirmatory question and it accounts for changes learners experience through their schooling progression. The third research question seeks to discover how learners can be supported to develop their identities from the concepts of identity as *doing.* The third research question takes into consideration that identity changes due to accessibility to active participatory pedagogy. At the same time, the concepts of identity as *negotiated experience* and identity as *doing* are not mutually exclusive, and they cannot be neglected in the concepts of identity as *becoming* as they strengthen understanding of different ways of how learners become certain types of individuals in mathematics classrooms. Thereafter, the research questions informed the research design, methods and analyses used in the study in order to make sense of data.

The second purpose of focusing on Wenger's (1998) social theory of learning was to understand the development of learners' identities in mathematics. The concepts of identity as *belonging* formed an important structure for discussing the review of literature. Anderson

(2007) highlighted that the modes of belonging are not mutually exclusive. Indeed, Wenger (1998) had suggested, for instance, that alignment coordinates imagination and engagement, while engagement serves as a central strand in developing learners' identities (Anderson, 2007). As such, the combinations of these modes of belonging can result in distinct qualities of communities of practice (Wenger, 1998).

2.5 Literature review

The following literature review intends to reinforce Wenger's (1998) broader social theory of learning by utilising constructions from Boaler's (2000b) study. However, other elements from the integrated perspectives on identity may be present and woven together within a given context to shape and support individuals' meanings in the mathematics classroom community. The subsequent review of literature concentrates on issues that influence learners' active engagement and participation in the classroom. But first, the study defines a mathematics classroom as a community of practice. Mathematics classrooms are understood as intense spaces for learning. The study intends to highlight strange behaviours that can be observed in the classroom, and points to relevant identity concepts as described by Wenger (1998) that can help mitigate such behaviours whilst motivating learners to stay interested in learning mathematics.

2.5.1 Mathematics classroom as a community of practice

A social theory of learning considers how learners within formal and informal groups in communities progress to develop identities in mathematics (Boaler, Wiliam, & Zevenbergen, 2000). A major component of learning for individuals is about becoming members of schooling communities (Davis, 1999, cited in Forster, 2000, p. 227). The phenomena of becoming community members through negotiations between individuals within networks of social and cultural relationships are called "communities of practice" (Lave & Wenger, 1991). In this case, schools are the recognized institutional structures where many communities of practice exist (Wenger, 1998). Hence, the mathematics classroom within a school can be identified as another community of practice (Goos, 2004).

The discussions in the next segments firstly focus on highlighting negative occurrences that can take place in the mathematics classroom, and thereafter conclude by deliberating on Wenger's (1998) description of a well-functioning community of practice. Eckert and McConnell-Ginet (1992) regarded a community of practice as an aggregate of people who come together around mutual engagement in an endeavour. From this narrow description, it emerges that members of the classroom community can engage in strange ways of doing

things from their past experiences within the practice (Holmes & Marra, 2002). Wenger (1998) pronounces that if learners fail to learn what is expected in classrooms, they are involved in learning something else instead.

Identities become an influential component to individuals' (in this case learners of mathematics) involvement in a manner that yield intended or unintended learning outcomes in communities of practice (Wenger, 1998). In other words, learners of mathematics are aware of what is expected from them in classrooms but they may opt for alternative learning practices. For example, when learners in stressful classrooms are given tasks from textbooks, they know how to implicitly appear busy but avoid internalizing and reflecting on their work for scrutiny (Boaler *et al.,* 2000). In this sense, learners protect themselves from the shame of not being able to demonstrate competence in knowledge that is expected from them by teachers, peers or themselves (Bibby, 2002). Hence, for Wenger (1998), the concept of identity as *negotiated experience* provides important contributions to how teachers can positively or negatively utilise learners' lived experiences to connect learning and identities of learners in mathematics classrooms.

When learning revolves around a teacher in mathematics classrooms, most learners have learned to nod their heads to portray sincere understanding towards elucidated concepts. In general, when learners in the classroom are asked to verbally confirm if they understand a concept, often than not, a teacher will get a 'chorus of voices' saying 'yes, we understand'. When single individuals are confronted to demonstrate understanding or competence, learners get into a defensive mode and resist participation (Boaler *et al.,* 2000). Learners inevitably embrace inappropriate behaviours when they are placed in teacher-centred mathematics classrooms (Holmes & Marra, 2002). Thus, some learners become anxious towards engaging with mathematics and suddenly become unsure of what is familiar and unfamiliar (Newstead, 1998). Because of such implicit occurrences, Wenger (1998) presented the concepts of identity as *doing* which promote collaborative, inclusive and reflective learning in classrooms.

In addition, joining a community of practice involves ways of talking to other members and ways of talking about the subject (Eckert & McConnell-Ginet, 1992). In this case, learners begin to formally and informally talk about the common language, rituals, stories and historical events of mathematics (Aschbacher, Li & Roth, 2010). For example, doing mathematics has been historically believed to be challenging. As a result, from what learners feel and think, they can develop negative attitudes towards mathematics (Boaler, 2002). In general, negative attitudes lead to poor performance in the future mathematical endeavours (Zan & Di Martino, 2007). The concepts of identity as *narrative* outline discursive formations

of how past and present experiences can influence future experiences of learning mathematics in communities of practice.

However, Wenger (1998) built on Lave and Wenger (1991) to define a well-functioning community of practice. In the community of practice, learners gain access to experts, and they may either perceive themselves to be members or aspire to membership in a community in which experts practices are central (Lave & Wenger, 1991). Wenger (1998) identified three dimensions to consider when describing communities of practice: *mutual engagement, a joint enterprise,* and *a shared repertoire.*

The concept of 'mutual engagement' permits learners to take charge of their learning in mathematics classrooms (Boaler, 2002). Boaler (2000b) argues that practices should give learners an active role in doing mathematics in order to prompt a sense of human agency which will allow them to negotiate, shape, and reflect upon their participation or non-participation in the classroom. In turn, learners will develop mathematical identities because they will be in good positions to exercise their own freedom and thoughts when engaging with the subject (Boaler *et al.,* 2000).

'A joint enterprise' supports the mutual engagement in the community of practice. A joint enterprise is characterised by its factors of persuading members of the community of practice to work together towards a common goal (Hughes *et al.*, 2007). Members become accountable to their mutual engagements because they have ownership of the community of practice (Chauraya, 2013). For learners in mathematics classrooms, for example, their common purpose might be to apply logical reasoning and critical thinking in order to make sense of the subject.

'A shared repertoire' gives members access to shared resources which have been "produced or adopted in the course of its existence, and which have become part of its practice" (Wenger, 1998, p. 83). The shared resources comprise of "routines, words, tools, ways of doing things, stories, gestures, symbols, genres, actions or concepts" (Wenger, 1998, p. 83). In Wenger's (1998) theory, the enlisted three dimensions (mutual engagement, joint enterprise, and shared repertoire) of a community of practice, alongside the modes of belonging, are critical sources of identity formation.

2.5.2 Development of identity through classroom practices

Boaler (1998, 2000b) advocated that classroom practices are extremely important in supporting learners to develop a positive identity. The discussions below are structured to entail three themes associated with developing identities (1. the interacting learner, 2. lack of

meaning, and 3. monotony) from Boaler's (2000b) study. Returning to Wenger's (1998) deliberations on identity, the modes of belonging (engagement, imagination, and alignment) contributed in structuring the following discussions. Considering the fact that the schooling system has specific learning outcomes, the concept of engagement as a mode of belonging became prominent in the discussions, as we will see below.

A focus on engagement

Firstly, how can teachers organise classrooms in a way that will allow 'an interacting learner' to engage with other learners (and the teacher) in discussions, and in sharing mathematical knowledge through collaborations and group work? Bibby (2009) explained that the concepts of teaching and learning are bound by unconscious emotional flows of relationships between teachers and learners. To forge these emotional relationships, teachers can begin to "treat learners as people, rather than simply learners of mathematics" (Boaler, 2000b, p. 388). McLaughlin (1994), cited in Boaler (2000b), claimed that the way teachers treat learners counts more in determining their attachment to education and the school (p. 389). Boaler (2000b) asserted that learners are aware that teachers cannot be their friends, but they expect at least that teachers make efforts to understand them and begin occasionally to talk to them about non-mathematics issues. This gesture provides learners with an opportunity to be "responsible young adults" (Boaler & Greeno, 2000, p. 190). In this way, learners are able to discuss mathematics with each other in a relaxed environment (Boaler, 1998, 1999, 2000b). In other words, teachers should transform classrooms into a life-like environment (Boaler, 2000b) and a scholarly home with opportunities to enhance the understanding of mathematics (Wenger, 1998).

In relation to the above paragraph, Boaler (2000b) conducted a study which revealed that students do not appreciate anti-social classroom environments where efforts at working together or even helping each other are curbed by teachers. In this study, one student pointed out that "it was annoying and off-putting" to get into trouble for trying to help other students. Boaler (2000b) affirmed that as much as adults forge professional relationships with colleagues to impact on job success, it was also important for teachers to encourage students' discussions in the classroom as this forms a strong basis for mathematical thinking and learning. This statement relates to Dewey (1938), cited in Boaler (2000b), who argued that "humans are inherently social beings, and interactions with people form the basis for life's experiences" (p. 390). In this regard, Boaler (2000b) reiterated that students must not lose out on the opportunity of discussing classwork in order to gain meaning from participating in the mathematics community.

Secondly, Boaler (2000b) argued that “lack of meaning” distances students from participating fully in the mathematics community (p. 384). This requires that teachers should shift from enforcing traditional practices where learners are expected to memorise and recall mathematical procedures (Boaler, 1998). Certainly, the traditional teaching approach requires teachers to concentrate on introducing mathematical concepts and procedures to students “in hope that students will learn and understand the procedures, as well as link the different procedures to the broader mathematical domain” (Boaler, 2000b, p. 384). Ross (1998) also argues that more learning results from doing mathematics rather than from looking at a teacher demonstrating methods and procedures on the chalkboard. In this way, learners tend to own mathematics if they engage in creating the subject themselves (Ross, 1998). Moreover, learners take responsibility for their own learning, and in turn, their identification increases towards mathematics (Boaler, 1999).

Consequently, learners must make sense of mathematics in order to develop their strong positive identities in mathematics (Boaler, 2000b). For learners to make sense of mathematics, Brodie (2009) advocates that teachers need to give learners tasks which allow them to explore, reason, and think creatively. Hence, Kabiri and Smith (2003) recommend that teachers must engage learners in open-ended mathematical tasks, questions or projects that have multiple responses or one response with multiple solutions. In the “Creating flexible knowledge in the mathematics classroom” article, Boaler (1999) highlights that learners who are encouraged to engage in open-ended mathematical tasks begin to like the subject. And when learners like the subject, it becomes the subject of their choice and they become more interested to the meaning of content whilst applying the content knowledge and understanding in the world (Boaler, 2000b). To put it differently, open-ended mathematical tasks allow learners to understand the subject and develop more flexible forms of knowledge that they are able to use in a variety of different situations, including the formal school assessments and the ‘real world’ (Boaler, 1999).

The effects of an ‘open-ended tasks’ approach contrast with the effects of a textbook approach in learning mathematics. To support this claim, Boaler (1999) identified these two teaching methods to be “completely different” (p. 10). As much as teaching using a textbook approach is easy and less time consuming (Goodson, 1991), it also reverses some gains of the open-ended tasks approach (Boaler, 2000a). In general, textbooks present examples of particular mathematical methods and then sets of exercises from which learners can practice the methods (Boaler, 1999). The role of a teacher in the textbook approach is to demonstrate techniques and methods on the chalkboard at the start of a class and set off learners to do one exercise after the other (Boaler, 1999). As a result, learners often rely on methods they have just been introduced to on the board and if questions require different

methods, they would often get answers wrong, or become confused as to what to do next (Bibby, 2009). In this regard, mathematics becomes a subject inclined towards the "collection of sums, rules and equations that simply needed to be learned" and solved by learners (Boaler, 1999, p. 12). Peter and Swing (1982), as cited in Boaler (1999), encapsulates these arguments to suggest that as much as the textbook approach keeps learners more on task whilst learners who engage in open-ended tasks spent a larger proportion of their lessons 'off task', it was this latter approach that enabled more learners to use mathematics in a range of settings (p. 15). At the end however, when learners are assessed on what they have learned from closed mathematics approaches in classrooms, their performance is lower than those of learners who engaged in the open-ended mathematical tasks approach (Boaler, 1999).

Thirdly, Boaler (2000b) identified "monotony" as another issue that needs to be discussed in order to characterise learners' mathematics experiences in classrooms (p. 383). Monotony can be described as the lack of variety learners experience from repetitive teaching approach in classrooms (Boaler, 1999, 2000b). In Boaler's (2000b) study, monotony emerged to limit learners' affiliation with the mathematics community. For example, in traditional systems of learning mathematics, learners would rely more on techniques and methods demonstrated to them by teachers at the front (Boaler, 1999). In turn, learners demonstrate their understanding of particular mathematical concepts by working through exercises from textbooks (Boaler, 1999). Thus, learners engage with mathematics exercises from one page of a textbook to the next page (Boaler, 2000b). In a situation when rules or methods do not work in an equation, learners would approach a teacher for more clues (Boaler, 1999).

To extend this notion, Boaler (1999) asserted that engaging learners in content-based activities can create a controllable and orderly learning environment. However, if the content-based activities present low-level questions that do not "ensure genuine participation and mathematical thinking" (Brodie, 2007, p. 4), learners often become "uninterested and uninvolved" (Boaler, 1999, p.11) in how they find those 'one right answer' which are often found at the back of textbooks (Boaler & Greeno, 2000) or from each chapter. In short, learners sit and work through many exercises, page by page, without really thinking about what they are doing (Boaler, 1997). Anderson (2007) confirms that learners come to believe that doing mathematics means getting the correct answers, often quickly. Thus, those who cannot get correct answers quickly begin to doubt their capabilities of doing mathematics (Anderson, 2007). In the process, they stop engaging with other learners to develop effective strategies for solving mathematical problems (Anderson, 2007).

The monotonous nature of school mathematics lessons becomes a distinguishing factor for learners between an enjoyable and a boring learning environment. In Boaler's (2000b) study, one learner asserted that enjoyable lessons are when they are occasionally exposed to different forms of tasks in mathematics classrooms. The different forms of mathematical tasks can include working on open-ended projects, investigations, and practical work (Boaler, 2000b). In any case, the variety of teaching methods does far more than making the lessons less boring; it also develops learners' mathematical knowledge, and so, they are able to negotiate meanings in the classroom (Boaler, 2000b).

The above discussions challenge the need for didactic teaching methods through a textbook approach. However, and in all fairness, studies (for example Brodie, 2009; Ross, 1998) do not dismiss the use of the textbook approach and the syllabus in classrooms. Instead, researchers (for example Boaler & Greeno, 2000) begin to recommend that teachers must de-emphasise "mindless drilling" (Ross, 1998, p. 252) of algorithms and procedures in classrooms. Rather, textbook activities and examination questions should be used in ensuring that learners are experiencing diversified teaching approaches in the classroom (Boaler, 2000b).

A focus on imagination and alignment

The other important features of developing positive learners' identity in mathematics include the imagination and alignment modes of belonging dimensions (Wenger, 1998). With respect to imagination and alignment, Anderson (2007) points out:

> Teachers and others in schools can consistently reinforce that mathematics is an interesting body of knowledge worth studying, an intellectual tool for other disciplines, and an admission ticket for colleges and careers (p. 12).

For me, there is no better way of enforcing the notion that mathematics is an interesting body of knowledge worth studying than to actually make it an interesting subject in the classroom. In this literature review, it has been discussed that learners enjoy lessons when teachers use a variety of approaches in mathematics classrooms. Also, the review has established that teachers can choose to transform classrooms into a more relaxed life-like environment, and a scholarly home in order for learners to make sense of mathematics. However, the development of identities through the imagination dimension extends beyond classrooms because learners often want to know relevant applications of mathematical knowledge in life (Suh, 2007). As Masingila (1994) argues, classroom mathematics should be the mathematics that will prepare learners for its application in all life situations. Thus, schools can present learners with opportunities to see themselves as mathematics learners

away from the classroom (Anderson, 2007). For instance, teachers and parents can invite people from outside schools to give talks about how they use mathematics to solve problems in their professions (Anderson, 2007). Sfard and Prusak (2005) look at this event as "linking identity to the socio-cultural context of learning" (p. 20). In addition, research (for example Suh, 2007) has shown that learners can also become aware of the usefulness of mathematics when they are required to reflect (by keeping logs and records) of any real-life problem that they themselves solved using mathematics.

Lastly, many students (and their parents) are unaware of the vast number of careers that require mathematical knowledge (Aschbacher, Li & Roth, 2010). For example, in sciences and engineering sectors, the participation of women in such professions remains disproportionally low (Dick & Rallis, 1991). Anderson (2007) argues that teachers (and parents) can foster the alignment dimension of shaping identities in mathematics by making learners more aware of possible career choices. For example, there could be learners who can be inspired to take teaching as their careers (Goodson, 1991). In addition, schools can encourage and support learners to attend career days which are often offered by universities and other stakeholders. At the University of the Witwatersrand, grade 11 and 12 learners are invited every year to attend Wits Focus Day. This is where learners are exposed to academic subjects so that they learn more about study options and possible career path choices available to them.

2.5.3 Classroom as a community of practice and identity

The concepts which formed the literature review are discussed further in order to connect them to certain other features that are associated with identity. The connections are specifically presented to relate classrooms as a community of practice with identity as practice, and identity as narrative. As we will see below, these relationships highlight the roles of classroom community members, particularly that of a teacher, when developing learners' identities in mathematics.

The classroom community as a social context with different backgrounds, views, behaviours, and expectations of its players has been identified as an intense source of learners' identities in mathematics education (Atweh, Forgasz & Nebres, 2001). The exploration of differences in roles of players becomes factors that emerge when examining learners' identities in mathematics. The roles of players influence the changes of learners' identities from time to time. Players in the classroom context are mainly teachers, learners and the discipline of mathematics.

Grootenboer and Zevenbergen (2008) located the teacher's role in a key strategic position (as shown in Figure 2.3 below) in the classroom community when developing learners' identity in mathematics. The role of the teacher dominates the classroom community. The teacher's role is followed by other defining factors of learning such as the curriculum, textbooks, and stories about mathematics. The teacher's dominance includes re-introducing mathematics to learners at first encounters of teaching in a new grade or phase. The re-introducing mathematics description acknowledges that teachers are not beginning with a blank slate, but in many respect it becomes a new start (Grootenboer & Zevenbergen, 2008). The teacher's role in influencing learners' mathematical identity seeks to bridge relationships between learners and the discipline of mathematics (Boaler, 2002). At the end, the teacher's role becomes finite and learners become independent enough to go further with an enabling mathematical identity.

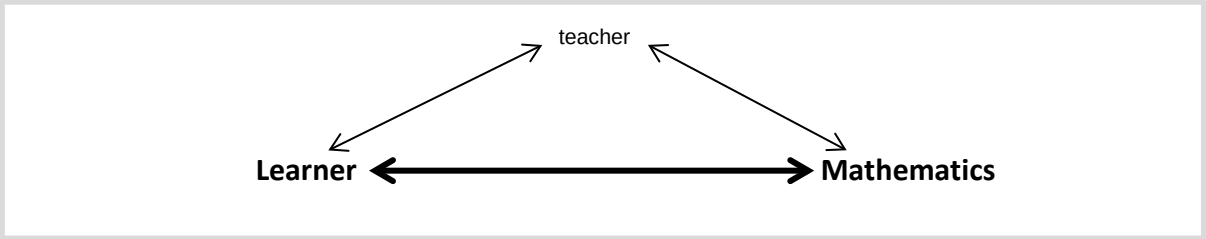


Figure 2.3: The relationship between learner and mathematics (Grootenboer & Zevenbergen, 2008)

Grossman *et al.* (2001) posited that learners fail to carry along relationships they have accumulated with the discipline of mathematics because of their memberships to a *pseudocommunity*. The pseudocommunity notion starts from acknowledging that members may have tendencies of acting as "if they are already a community that shares values and common beliefs" (Grossman *et al.,* 2001, p. 955). Many contributing factors to a pseudocommunity include some concerns that were raised previously in this study, such as teacher-centred classroom, rote learning, monotonous teaching methods, and a lack of learning resources across many rural and township schools especially in the South African context. However, in this instance, the notion of pseudocommunity analyses of learners' experiences can concentrate on general narratives which maintain superficial levels of agreement during conversations (McGraw *et al.,* 2003). Within this context, and as per the problem statement, learners may not question the teacher's role or challenge each other to negotiate meaning to yield appropriate actions towards contributing in the production of mathematical knowledge and understanding (McGraw *et al.,* 2003). As a result, learners with certain abilities figure out ways of passing mathematics whilst they tend to stop advancing with the subject. On the other side, learners who cannot figure out ways of passing get

excluded by the schooling system, whilst pretending to know what it takes to pass or pretending to have positive relationships with the subject.

2.6 Summary

This chapter has firstly described a common definition of identity. It was suggested that a certain kind of individual, as being recognised by the mathematical community at a given time and space, can change from time to time during interaction, and, can change from context to context (Gee, 2001). Secondly, particular definitions and different ways of viewing learners' identities in mathematics were expressed by integrating Gee's (2001), Wenger's (1998), and Sfard and Prusak's (2005) perspectives from their social learning theories. However, Wenger's (1998) broader social theory of learning was selected as the theoretical framework to frame the study. By purposefully selecting Wenger's (1998) broader social theory of learning, the theoretical framework guided the structuring of the research questions which informed the methodology and research design - the next chapter. The theoretical framework also informed the central concepts of the study; namely the mathematics classroom as a community of practice, and the development of learner identity. Lastly, the teachers' roles were described as dominating mathematics classrooms, whilst at the same time, their roles were suggested to be finite and temporary in order for learners to gain enough confidence when working independently with each other in negotiating meaning during learning and teaching practice.

CHAPTER 3

METHODOLOGY AND RESEARCH DESIGN

3.1 Introduction

This chapter firstly enumerates different research approaches (with examples) that have been applied to studies of emotional and cognitive reactions of learners towards mathematics. The purpose of reviewing literature on previously utilised methodological approaches is to demonstrate a need to explore features of mixed methods research. Secondly, the mixed methods research design is discussed whilst showing which learners are studied, and from which type of school. Thirdly, the study concentrates on how the data sets were collected for analysis in order to answer the research questions. Lastly, the study account for rigour in the research.

3.2 Approaches to studying learners' emotional reactions

Most studies of emotional notions of learners (such as identities, attitudes, and anxiety) in mathematics diversify to employ either qualitative research, quantitative research or mixed methods research approaches (Turney & Robb, 1971). The qualitative approach preceded other approaches for the development of identities and other emotional reactions towards mathematics (Darragh, 2016; Lerseth, 2013). For example, Boaler (2000b) compared and contrasted the impact of different teaching and learning methods in relation to how it affects mathematical learners' ability which in turn develops their identities. The author grouped common themes which emerged from interviews, questionnaires, and from her own observations of both classroom and school environments. In this Boaler (2000b) study, among other things, students were asked to describe mathematics lessons whilst highlighting particularly those lessons that they liked or disliked in relation to their past, present, and future experiences within the classroom environment. Then, the author discussed the most dominant themes – the interacting learner, lack of meaning, and monotony – that characterised learners' views of their school mathematics learning environments in respect to different teaching methods.

In many qualitative studies (for example Boaler, 2000b; Boaler & Greeno, 2000; Bibby, 2009), unstructured or semi-structured interviews are used to avoid imposing researchers' views from the outside on understanding and perspectives of identity formation in mathematics. For example, to ensure that data is collected within the context of studying learners' identities in its natural form, interviews (or questionnaires) can be open-ended in

order to concentrate on exploring learners' views and perceptions in their experiences of doing mathematics (Bibby, 2002).

Alternatively, taking a quantitative approach, Fennema and Sherman (1976) provided a number of scales suitable for measuring emotional factors of learners' towards mathematics. Researchers can select scales that are compatible to their studies. Researchers can gather scores from measuring instruments such as closed questionnaires to identify emerging dimensions that are related to the learning of mathematics (Fennema & Sherman, 1976). For example, Newstead (1998) used a quantitative approach to analyse pupils' anxiety in mathematics. The focus for Newstead's (1998) study was to measure and compare the mathematics anxiety of pupils taught in a traditional manner with that of pupils whose teachers adopted an alternative approach emphasising problem-solving and discussion of pupils' own informal strategies. In this exemplified study, the emerged dimensions ranged from feeling at ease to feeling distinctly anxious which is different to other emotional reactions like enjoyment or confidence in relation to the learning of mathematics (Fennema & Sherman, 1976).

In quantitative approaches, researchers often design closed questionnaires to control conditions and rule out variables that cannot be accounted for by their studies (Turney & Robb, 1971). In some surveys, researchers (for example Dick & Rallis, 1991) use forced-choice format. For instance, participants will have to somehow agree or disagree to statements or questions. Moreover, the validity of closed questionnaires may be supported by interviews where some core statements or questions may be repeated, and the reliability may be confirmed by statistical analysis (McMillan & Schumacher, 2006).

Finally, as it will be established in the present study, a mixed methods approach combines qualitative and quantitative approaches (McMillan & Schumacher, 2006). Many writers (for example Creswell, 2004; Creswell & Plano Clark, 2007; McMillan, 2012) identified the following three mixed methods research designs: triangulation, exploratory and explanatory. Johnson and Onwuegbuzie (2004) refer to triangulation as a research design which seeks "convergence and corroboration of results from different methods and designs studying the same phenomenon" (p. 22). Exploratory design is a two-phase research design which firstly gathers data from qualitative methods and then follows that by quantitative processes (McMillan, 2012). Typically, this design uses the initial qualitative phase with a few individuals to identify themes or ideas for the larger-scale quantitative part of the study (McMillan, 2012).

Many researchers (for example Geldenhuys, Kruger & Moss, 2013) have relied on the explanatory research design to investigate emotional reactions of learners in mathematics.

This is another two-phase research design. Researchers firstly collect data by using quantitative methods and then apply qualitative methods to explain results that are obtained from quantitative methods (Creswell, 2004). For example, researchers self-design a closed questionnaire to collect data for quantitative analysis. As the next step, researchers allow participants to further explain their views by using open-ended questionnaires or interviews. The rationale of this approach is that quantitative analysis provides a general picture of the research problem, and to define, refine and explain the general picture, qualitative processes can be applied for further analysis (Creswell, 2012).

3.3 Proposed methodological approach

Given the complexity of exploring learners' identities in mathematics, it was important to mix both qualitative research (QUAL) and quantitative research (QUAN) in order to best answer the research questions of the study (Onwuegbuzie & Leech, 2004). In this study, the first and third research questions are more exploratory, whilst the second research question is a confirmatory type of question. According to Teddlie and Tashakkori (2009), such research questions (and researchers' beliefs) inform the appropriateness of employing a mixed methods research, and its fitness to a pragmatic perspective. Furthermore, Barmby and Bolden (2014) recommend a mixed methods research to research emotional and cognitive reactions of participants in mathematics education.

When Jennifer Greene was asked in Johnson, Onwuegbuzie and Turner (2007), she stated that mixed methods research is an approach to investigating the social world that ideally involves human phenomena with a diversified interpretation of knowing, "all for the purpose of better understanding" (p. 119). In this study, the qualitative approaches describe how the learners interact with each other and teachers in the mathematics classrooms as a community of practice, and the study also quantitatively assess trends of different interaction types in order to develop a rounded understanding of learners' identities. Moreover, given the background of the study, learner identity was viewed from a socio-cultural perspective. According to Kempe (2014), citing Wertsh (1998), taking a socio-cultural approach enables the researcher to 'live in the middle' and view data from different perspectives provided by different contexts, and to identify ways in which the intersecting identities of the researched participants enhance the interpretation of the findings (p. 21).

Johnson and Onwuegbuzie (2004) referred to the mixed methods approach as a "class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (p. 17). In a continuum that ranges from pure QUAN to pure QUAL a researcher can decide how much of

QUAN and QUAL approaches to consider in her study (Johnson *et al*., 2007). Within this regard, the present study used an open-ended questionnaire (QUAL component) to develop a Likert-scale questionnaire (QUAN component), and returned back to expand QUAL processes through interviews. That said, in sequential mixed designs, data sets are collected and analysed from one phase of a study and used to inform other phases of the investigation (Teddlie & Tashakkori, 2009). The research design of this study met such a definition.

3.3.1 Mixed methods research design

Sequential mixed designs occur when an individual researcher or team of researchers alternate the qualitative and quantitative methods across three phases (Creswell & Plano Clark, 2011; Tashakkori & Teddlie, 2010). Typically in these designs, a researcher first collects and analyses the qualitative data. The quantitative data is then collected and analysed as the second phase. The benefits of quantitative analysis include building on the qualitative results obtained in the first phase to develop instruments as an intermediate step between the two phases. The third phase of these designs, which is the qualitative data, helps to explain, or expand, on the quantitative results from the second phase. All three phases are sequentially connected for the purposes of addressing a set of incremental research questions that advance one programmatic research objective (Creswell & Plano Clark, 2011; Teddlie & Tashakkori, 2009).

Greene, Caracelli and Graham (1989) identified the following five broad purposes of mixed methods research designs: triangulation, complementarity, development, initiation and expansion. Development, complementarity and expansion were applied for the purposes of this research study. Most aspects of development appear to have superseded other explanations in this study. The study valued the idea of developing the closed questionnaire from the open-ended questions. The complementarity aspects came to play in the idea of seeking enhancement and clarification of the results from the Likert-scale questionnaire when comparing the results from the open-ended questionnaires (Johnson *et al.,* 2004). Furthermore, the importance of using the results from the closed questionnaire was kept in mind to inform the expansion purposes for the semi-structured interviews which was the third phase of data collection of this study (Johnson *et al.,* 2007).

Many writers (for example Creswell *et al.,* 2011; Johnson *et al.,* 2007; Maxcy, 2003; Tashakkori *et al.,* 2010) recommended that researchers use pragmatism as an umbrella philosophy for mixed methods research design. A pragmatic approach distances itself from the metaphysical principles (e.g. epistemology and ontology) associated with the paradigm disputes, and instead, it helps improve communication among researchers in order to

advance knowledge (Johnson *et al.,* 2004). Also, a pragmatic approach takes a special interest in combining methods in order to provide meaningful answers to research questions at hand (Johnson *et al.,* 2007). Therefore, pragmatic philosophical assumptions for mixed methods research balance the act of objectivity and subjectivity within the meaningful use of research language (Johnson *et al*., 2004).

However, post-positivist philosophical assumptions are preferred to implement quantitative research methods which, in this research, have been developed from the contributions of qualitative research methods, and visa versa (Creswell *et al.,* 2011). Qualitative research methods are respectively framed in constructivist philosophical assumptions (Creswell *et al.,* 2011). Differences of philosophical assumptions, at different stages of mixed methods research design, addressed different aspects of research questions that were guiding the study (Creswell, 2009). To account for objectivity, post-positivists find the need to identify and assess causes that influence outcomes of an inquiry (Creswell, 2009). The researcher claims knowledge by reducing information with different vast variables to give comprehensive message from fewer correlating variables (Field, 2009). The researcher seeks to discover the number of factors influencing variables and to determine which variables 'go together' (Yong & Pearce, 2013) to yield an unassuming reality from multiple perspectives.

Constructivism is typically associated with qualitative approaches. It seeks to understand and explain phenomena formed through participants' interpretations and their subjective views (Creswell *et al.,* 2011). For Tashakkori *et al.* (2010), constructivists hold a worldview that "there is no structural gap between human beings and their environments because we are participants in an ever evolving universe" (p. 112). Participants provide their understandings that are shaped by social interaction with others and from their own personal experiences (Creswell *et al.,* 2011). As such, the research questions of this study were explained and elaborated using qualitative approaches which were shaped by individuals within the 'mathematics classroom as a community of practice'.

To conclude this section, I have described a featured research design whilst deliberating on its purposes. The research design was philosophically framed in pragmatic interpretations which offer researchers an empirical space to practically answer their research questions using procedures from both qualitative and quantitative approaches. Tashakkori *et al.* (2010) described research design as a detailed plan for conducting a research study. Based on the described research design, the study adopted a sequential mixed design model. The research design model is depicted in Figure 3.1 below.

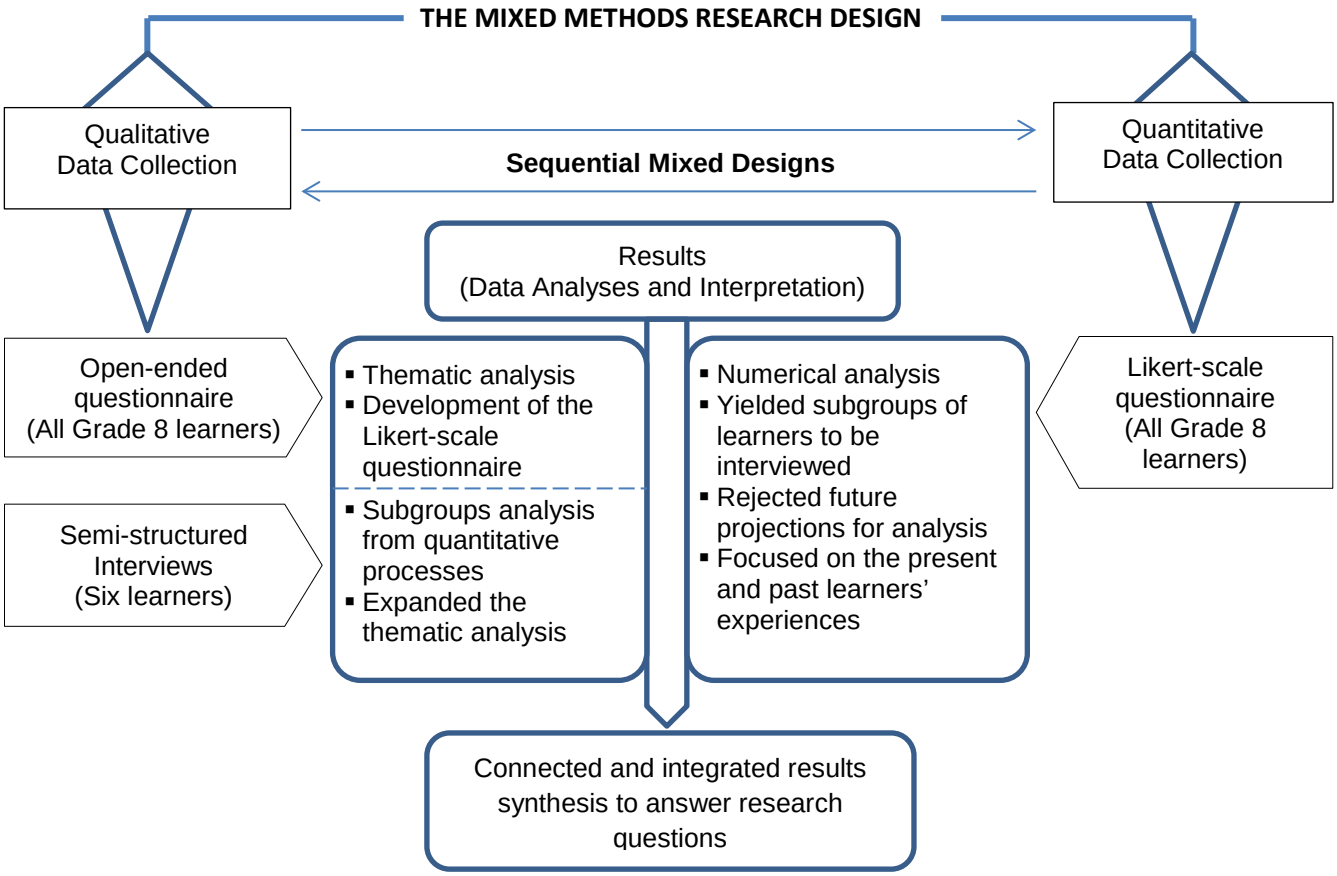


Figure 3.1: The adopted mixed methods research design model (Tashakkori & Teddlie, 2010, p. 325)

3.3.2 The participants

In 2016, Grade 8 learners from a Johannesburg school were asked to participate in the larger project. The school has positive working relationships with the university. The primary objective of the larger project was to improve Grade 8 learners' identities when it comes to the learning of mathematics. Broad sets of information were gathered using questionnaires, interviews, observations, audiotaping and videotaping for the project. This study became the forepart of the larger project. The study concentrated on exploring learners' identity in mathematics.

During my involvement in all the processes of gathering information with other researchers within the project, I had this Masters study in mind. My roles in the project included leading the processes of collecting information using both the open-ended and closed questionnaires. Thus in the next sections below, and given the above contexts, I use "we" in my writing to acknowledge the contributions of other researchers. What follows next are some reasons for selecting Grade 8 learners to participate in this study.

There are many reasons for selecting Grade 8 learners to participate in a research study of this nature. For one, as highlighted in the literature, secondary school learners are at that stage where they can reflect back on their primary school experiences. As a result, there are more chances that grade 8 learners can value opportunities that are carried out from understanding the development of mathematical learner identity. Secondly, it is on record that Annual National Assessments (ANA) results in mathematics have been shockingly low (DBE, 2014). For example, in 2014, the average national percentage of grade 9 learners who wrote and passed the mathematics assessment was 11% (DBE, 2014). ANA performances are corroborated by the results of international studies such as the Trends in Mathematics and Science Studies (TIMSS), and this has called for interventions that will focus on grade 9 learners. However, most knowledge content that is assessed in the ANA for grade 9 learners is not based on the grade 9 curriculum, therefore the improvement of learning and teaching strategies are equally needed to be directed to lower grades (DBE, 2014). This links to the fact that grade 9 results are used in most schools to place learners as to which subject choices they can take in grade 10 onwards (DoE, 2005). Lastly, there is an opportunity that junior secondary school learners can be motivated through the modes of belonging (engagement, imagination and alignment), as discussed in the review of literature, to positively influence and develop their mathematical identities.

The number of learners sampled to participate in filling both the open-ended questionnaire and the Likert-scale questionnaire was 117. This is the total number of four grade 8 classes from the chosen school. Each classroom has an average of 29 learners. The advantage of getting all Grade 8 learners to participate in these first two phases of data collection (details to follow below) was to get a diversity of views from the wider spectrum of learners. The sample size was large enough to gain a better insight into the learners' views about mathematics (Cohen, Manion & Morrison, 2011), and enable greater reliability when using exploratory factor analysis (Yong & Pearce, 2013).

Six learners were interviewed. Interviews are time-consuming by their nature (McMillan & Schumacher, 2010), and the small number of the interviewed learners was satisfactory as interviews were intended to contribute to adding value to the open-ended and closed questionnaires. The six learners were chosen using stratified purposeful sampling. Two learners were chosen purposefully from learners who were found to have demonstrated drastic changes from negative views in the past to positive views when doing mathematics in the present. Another two demonstrated opposite changes in their views. Another two learners were randomly chosen from the group which was consistent with the majority views about doing mathematics. According to McMillan (2012), stratified purposeful sampling

ensures that adequate numbers of participants that can be examined intensely are selected from different subgroups.

The school is a technical school. This implies that grade 9 learners do not have an option of doing Mathematical Literacy when they advance to the Further Education and Training phase. Mathematical Literacy has been highlighted in the literature to be an easier subject choice for learners when compared to Mathematics. Hence, the learners were equally expected to identify with mathematics positively and pass the subject in order to not face exclusion by the schooling system.

Furthermore, the school is closely located to the university. Mixed methods research requires more time and they can be costly (McMillan & Schumacher, 2006). The close site location allowed the mixed methods research process to conveniently take place. In the three phases of data collection for this research, there were many back and forth trips taken between the university and the school. Mixed methods research allows the researcher to return to the field to collect more data at any given moment when needed (Creswell, 2009).

3.3.3 Methods of data collection

The present research set up three sequential phases for data collection. First, we created a questionnaire with open-ended items. Second, we used the responses collected in the first phase to develop a Likert-scale questionnaire. Lastly, participants were interviewed. Below each phase of data collection are discussed whilst making deliberate attempts to support claims made in the introductory paragraphs of the mixed methods research design above.

Open-ended questionnaire (QUAL component)

Learners responded to the following three open statements: (1) ‘Describe doing maths when you were younger’; (2) ‘Described doing maths at the moment’; and (3) ‘Described doing maths when you get older’. See Appendix A for the copy of this open-ended questionnaire. The structure of looking at learners’ past, their present experiences, and their future projections was adopted from the study by Gardee (2016). As discussed in the theoretical framework, Wenger’s (1998) definitions of identity as practice, particularly that of identity as *becoming,* accommodate this structure of examining learners’ experiences of learning. Learners were asked to write two or three sentences when responding to each statement of the questionnaire. As highlighted in the literature, it was important to keep the statements open in order to explore different views for learners. The use of open questions allows participants to freely state their views (in their own terms) about the subject (Agheyisi & Fishman, 1970). In other words, open questions invite honest views and minimise what

McMillan (2012) called the ‘response set’ where participants tend to provide responses that they think are acceptable to the society.

Open-ended questionnaires can lead to irrelevant and redundant information (Cohen *et al.,* 2011). However, in setting the objectives for this instrument, the open-ended statements were structured in such a way that they directed participants to respond about the intended subject. The idea was to generate issues that needed to be addressed in data analyses (McMillan & Schumacher, 2006). Within this sense, questions followed proposed definitions from the literature that learner identity changes from time to time according to how mathematics is presented at that present moment. Wenger (1998) posited that the positive changes of learner identity are encouraged through active participatory pedagogy, and hence choosing the wording ‘doing maths’ was an attempt to get learners to reflect on their actions and their experiences of learning mathematics. Also, there was an attempt to carefully phrase the statements in such a way that learners broadly shared their thinking of doing mathematics from their “social experiences of living in the world” (Wenger, 1998, p. 55) by avoiding including wording such as ‘for you’ that would have narrowed down responses to learners’ personal attributes of learning mathematics. We therefore anticipated views that entailed factors of learner identity such as beliefs, attitudes, perceptions, talks, solving problems, alignments and others to emerge from the questions.

In general, using open-ended questions can lead to respondents overlooking instructions because they are occupied with the task of writing responses in their own words rather than reading the instructions or statements (Cohen *et al.,* 2011). As such, the instructions were read to learners. We also made ourselves available to assist learners with more information should they encounter problems with the questions.

Closed questionnaire (QUAN component)

It is standard practice that open-ended questions can be used to develop closed questions (Cohen *et al.,* 2011; McMillan *et al.,* 2006). In this step, we collected all the responses from the open-ended questionnaire, categorised them according to their themes, and selected statements at random to develop a Likert-scale questionnaire (see Appendix B for the copy). I shall return to give specific descriptions of how the closed questionnaire was developed in the methods of analysis. At this point, I wish to elaborate more on why the closed questionnaire was developed.

According to Cohen *et al.* (2011), there is a danger of assuming that the respondent will have an instant viewpoint about all the matters from a questionnaire. As such, we had hoped that the closed questionnaire on the same subject would give the participants a second

chance to state their experiences of doing mathematics. On the other hand, closed questions increase the level of confidence of participants and allow them to provide more reliable information (Johnson *et al.,* 2007). In this case, the qualitative technique in phase one complemented the quantitative technique of the second phase. Johnson *et al.* (2007) argued that the researcher can be more confident about the data collected because of its authenticity.

There is an issue of choice of vocabulary when learners are required to fill a closed questionnaire designed by the researcher. Hence, the development of closed questions from the open-ended questionnaire responses lessens the gap between the researcher and the participants (Cohen *et al.,* 2011). The participants barely misunderstood the questions or statements from the closed questionnaire. We anticipated fewer unfilled questions.

Semi-structured interviews (QUAL component)

In planning the strategies for data collection, it was important for this study that the interview questions were worded in order to keep the subject in mind. See Appendix C for the copy. The proposed worded questions for this phase were open-ended, and the thinking behind them was to conduct semi-structured interviews that will provide an in-depth understanding about how Grade 8 learners identify with mathematics. As McMillan and Schumacher (1993) remark, interviewees can be encouraged to respond open-endedly when using semi-structured interviews. In this case, interviewees were offered opportunities to provide individual responses (McMillan & Schumacher, 1993), whilst the interviewers had an opportunity to probe for further clarity around aspects of research interest. The purpose of these interviews sought to expand the breadth and range of the research (Johnson & Onwuegbuzie, 2004).

Given the nature of semi-structured interviews, it was expected that respondents may now and then divert to talk about their areas of interest. However, the strategy of allowing respondents to divert from the subject gets them to relax and return to talk more in detail about the subject once they are probed to share more information. In Cohen *et al.'s* (2011) terms, interviewees must be given space for spontaneity. In addition, Creswell (2012) argues that stories are narrated from certain chronological perspectives to give participants more voice. Hence, it becomes important to audiotape interviews as it may be difficult to take down notes whilst the interviewee is talking (McMillan & Schumacher, 1993). Indeed, interviews for the present study were recorded and transcribed for data analysis. Hence, there were multiple opportunities to go back and listen to the recordings to filter explicit and relevant responses for data analysis (McMillan & Schumacher, 1993).

Cohen *et al.* (2011) proposed that interviews must be taken as a social encounter. To put it differently, interviews must be seen as two or more people exchanging views on a topic of mutual interest. As such, we were obligated to set up an interview room with minimum interruptions, and abide by the 'rules of the game' (Cohen *et al.,* 2011). Firstly, interviewers were introduced by their first names, and not with their surnames and titles. According to Mauthner (1997), this act establishes a tone of informality to gain learners' cooperation. Secondly, we were careful when explaining the purpose of the interview. For example, we emphasised the fact that 'we wanted to find out more about their views' rather than to say that 'we are researching learners' identities in mathematics'. This gesture establishes rapport and participants may be sincere in their responses to allow data accuracy at the end (Cohen *et al.,* 2011). Thirdly, we considered 'latitude' to pursue a wide range of responses (McMillan & Schumacher, 1993). Latitude in this context implies the need to allow participants to freely answer questions without strict control as some questions may have different answers. For example, one would say 'please tell us more' as a follow up probe to get the learner to share more insight or a different answer to a question. This also led to clarification. Fourthly, to lessen the language barrier, the interviewers were pleased to repeat questions and even explain them for clarity. The interviewers restrained from leading participants to respond to closed questions that may support certain point of view (McMillan & Schumacher, 2010), rather they were patient and waited for the responses. Other conceptions of the interview will follow in other sections, but next, the methods of data analysis are discussed.

3.3.4 Methods of data analysis

Data analysis also followed a three-phase process. To present the integrated mixed analysis, (1) the study analysed responses from the open-ended questionnaire using inductive data analysis; (2) that step was followed by the analysis of the closed questionnaire using exploratory factor analysis; and (3) finally transcripts from the interviews were analysed through predetermined categories to expand on the themes that emerged from the open-ended questionnaire.

Open-ended questionnaire (QUAL processes)

All filled open-ended questionnaires were collected from the participants. Each filled questionnaire was numbered for later administrative purposes. To get started with data analysis, McMillan and Schumacher (2006) recommend that the researcher can "develop an organising system from the data" (p. 368). We grouped data from generally reading learners' statements about mathematics. We needed to familiarise ourselves with the collected data. The idea was to get a general sense of the study (Creswell, 2009). In general, the learners

believed that mathematics ‘was easy’ in primary school, then it ‘got hard’ in Grade 8, and it will be ‘even harder’ going forward.

When coding data from open-ended statements, we firstly looked for words (in this case, ‘easy’, ‘hard’, and ‘harder’) which fitted the groups (Cohen *et al.,* 2011). In order for words to fit the groups, meanings were taken into account (McMillan & Schumacher, 2006). That is, we then fitted the words with similar meanings. As a simple example, ‘hard’ will get together with ‘difficult’ or ‘challenging’. This system yielded another group when learners have, for example, written mathematical symbols or examples and provided explanation outside our initial worded groups. As informed by McMillan & Schumacher (2006), it was here where we had to ask ourselves, ‘What were these learners talking about or implying by providing such information?’, and thus we looked for the same meanings from different contexts in order to fit them to our initial groups. The issue of overlapping (or duplicating) factors was taken into consideration. If statements overlapped, we chose one group where we thought it fitted the most. At this point of interim analysis (McMillan & Schumacher, 2006), we were able to get a glimpse of where the study was going when compared to our planned strategies for data analysis. The interim analysis stopped looking into further details for each group. Cohen *et al.* (2011) cautioned researchers that trying to explain data from this grouping approach can be cumbersome. Similarly, in this case, interim analysis from this approach became superficial in dealing with the issues of learner identity in mathematics.

However, it was interesting that within the initial groups, learners were determined to justify or give reasons for their statements. In other words, learners were not giving two or three statements about mathematics. Instead, it was one statement with a ‘but’ or a ‘because’ that was followed by another statement(s). As McMillan and Schumacher (2006) recommend, there was a need to continue to refine our coding system. Going forward, the study looked at the learners’ justifications and their reasoning. It was at this stage where common themes were organised using inductive data analysis method. Themes were carried over in order to explain hypothesis, different contexts of learner identities, and more importantly, explore the development of other instruments for further data collection. McMillan and Schumacher (2006) argue that the significant purpose for qualitative analysis is to look for systematic processes of categorising, synthesising, comparing, and interpreting data to provide explanations of particular interest in the study.

Closed questionnaire (QUAN processes)

To account for how the closed questionnaire was developed, the point of departure is that the filled open-ended questionnaires were numbered when they were collected. The reason for numbering them was to randomly pick filled questionnaires to develop the closed

questionnaire. In this case, EXCEL was used to pick questionnaires at random. The study had developed themes from the open-ended questionnaire with three statements. From the first open-ended statement that was 'Describe doing maths when you were younger', the major theme was called 'understanding in statement 1' and it was present in about two thirds of the data. From the second open-ended statement that was 'Describe doing maths at the moment', the major theme was named 'understanding in statement 2' and it was just below two thirds of the data. And from the last open-ended statement that was 'Describe doing maths when you get older', the major theme was 'motivation in statement 3' and this was just above one third of the data. See summary of themes with their percentages in the next chapter. At the end, a total number of 36 random statements were chosen from the major themes (15 statements from 'understand in statement 1', 14 statements from 'understanding in statement 2', and 7 statements from 'motivation in statement 3') to form a 36-item Likert-scale questionnaire – 36 items were deemed adequate for the study. We ensured that the statements were not repeated from any particular theme. If repeated, one statement was discarded and another statement from the related theme would be randomly chosen. We limited statements to a single idea or concept by adding or removing odd words for clarification. This technique was informed by Barmby, Bolden and Raine (2014).

This became the second phase for data collection, and learners responded by ticking their boxes of choice from strongly agree, agree, neither agree nor disagree, disagree, to strongly disagree per given statements. McMillan and Schumacher (2006) highlight that rating scales are mostly used in questionnaires because they allow fairly accurate assessments of emotional reactions from participants. This is because emotional reactions such as beliefs and attitudes are thought of in terms of gradations (McMillan & Schumacher, 2006). When the learners finished filling the Likert-scale questionnaires, they were asked to check if they did not inadvertently skip any statement (Cohen *et al.,* 2011). This gesture contributed to the quality of research.

The Likert-scale questionnaire data was analysed using SPSS. From the SPSS packages, exploratory factor analysis (EFA) was used to determine which dimensions emerged strongly from the data. In this case, two dimensions emerged from this analysis. The learners were relating more to their experiences of 'doing maths' in the past, and to some degree the learners shared experiences of 'doing maths' at the present moment. The future projections of learners did not come out as a coherent dimension. As a result, the focus of the study for further analysis, synthesis and interpretation eliminated future projections of learners. A scatter plot of learners was presented using the two identified dimensions to categorised learners for the stratified purposeful sampling of learners that were to be interviewed. As mentioned previously, three categories of learners were observed, and two participants per

category were interviewed to explore mathematical learner identity with another instrument – the interviews.

The interviews of six individual learners (QUAL processes)

The interviews had two parts. One, it followed the same structure as the open-ended questionnaire, which adopted the explanations of identity as *becoming*. However, the questions were more directed to accommodate both identity as *negotiated experience* and identity as *doing* as described in Wenger's (1998) social theory of learning as our theoretical framework. In practical terms, the interviewers asked the interviewees about their experiences of doing mathematics in the past, in the present, and about their future projections. As follow up questions, for example, learners were asked how they were taught or what did they enjoy about learning mathematics. Two, the questions were extended to explore ways of developing or improving mathematics learner identity from the learners' perspectives. This part reflected on the issues covered in the literature review which focused on classroom practices. Yet again, the nature of the interview was semi-structured. The interviewers were free to modify the sequence of questions, change the wording, explain them or add to them (Cohen *et al.*, 1994).

As highlighted above, this phase of data analysis followed a qualitative process. That is, data was organised, analysed, synthesised and interpreted using qualitative processes (McMillan & Schumacher, 2006). As such, data was coded to develop themes. We used predetermined subcategories to develop themes. Subcategories were guided by the research questions, and the themes were: identity factors, pedagogy, and cause of change (Cohen *et al.* 2011). More details of data analysis from the interviews will be discussed during the sequential reporting of the results in the next chapter. The interviews analysis depended on some outcomes based on both the open-ended and closed questionnaires analysis.

Consolidation of data analysis

Creswell (2009) encourages the need to consolidate data analysis. The study has demonstrated links of how each phase of the data analysis are connected. The three key concepts from identity as practice – identity as *negotiated experience*, identity as *doing,* and identity as *becoming* – were found to be appropriate for analysing different pieces of themes from both the open-ended questionnaire and interviews (Srivastava & Thomson, 2009). However, going forward, identity as *becoming* received lesser consideration in the analysis framework since the analysis of the closed questionnaire objectively restricted the study to concentrate on the learners' past and present experiences. Table 3.1 below shows the two characterised analysis frameworks.

Identity as *negotiated experience* implies learners identity that is developed from treatments they receive from their "daily engagement" (Wenger, 1998, p. 150) in the community of practice. For example, learners are justified to withdraw their engagement in the classroom if getting wrong answers from activities permits others to pass hostile comments or gestures towards them. So for instance, learners in some classrooms go as far as laughing if a learner provides an incorrect answer to the teacher's question. Moreover, on the other hand, identity as *negotiated experience* provides positive inferences in the formation of self-images when learners receive encouraging remarks from the teacher and other learners in mathematics classrooms (Wenger, 1998). The process of analysing identity depends on how events play out in the classroom at the present moment. The focus of analysis became whether teaching and learning environments were supportive or dismissive towards learners' social interpretations.

Identity as *doing* refers to knowing who we are by being exposed to what we understand, usable, negotiable, and familiar about the community of practice (Wenger, 1998). Members are offered opportunities to interpret usable information in order for them to identify themselves as knowers of different concepts in the community. In a community of practice, members find ways of working together on the familiar concepts through mutual engagement (Wenger, 1998). On the opposing end, "we know who we are not by what is foreign, opaque, unwieldy, unproductive" (Wenger, 1998, p. 153). A standard of analysing data focuses on relationships of understanding mathematics from collaborative learning perspectives.

Table 3.1: Identity as practice – Learners' identity analysis frameworks

Characterisations	Key aspects for coding
Identity as *negotiated experience*	Learning experiences through participation
	Self-images in relations with others
	Motivating learning environment
	Effects of engaging with the teacher
Identity as *doing*	Display of competence in the subject
	Collaborative learning perspectives
	Why learners engage in activities
	Accountability to an enterprise

As much as the data analyses were conducted per each phase, and per each thematic outcome, the ultimate goal of the analyses was to draw conclusions from Grade 8 learners' views and further highlight possible generalisation of findings that can contribute in identity research.

3.4 Rigour in the research

Researchers have a responsibility of conducting studies that are open for criticism and evaluation (Long & Johnson, 2000). Thus, researchers are required to abide by the shared values, rules and standards of how all research studies are measured for quality and rigour (Davies & Dodd, 2002). Rigour is characterised by the trustworthiness of the research (Chauraya, 2013; Golafshani, 2003; Shenton, 2004). In general, such accountability and evaluations are centred on assessing validity and reliability of research (Long & Johnson, 2000). It is however understood that reliability is a consequence of the validity in a study (Cohen *et al.,* 2011). Furthermore, ethical considerations become an integral part of rigour in research (Gorard & Taylor, 2004).

3.4.1 Validity

The nature of mixed methods research intends to promote the quality of research by drawing strengths and discounting weakness from paradigm characteristics. Onwuegbuzie and Johnson (2006) advocated that "strengths and non-overlapping weaknesses" (p. 51) from different paradigms can complement each other to enhance validity. The present study applied a sequential mixed design by switching between qualitative methods to quantitative methods. The study followed what Onwuegbuzie and Johnson (2006) described as "bilingual nomenclature" (p. 55) by using language of validity that is acceptable from both qualitative and quantitative communities of researchers. That is, the study used language for validity that was aligned with that of the philosophical stances (post-positivism and constructivism) adopted in the mixed methods research design. Within this explanation, the next segments describe an account for validity for each method of data collection.

Qualitative validity (The open-ended questionnaire)

This section seeks to account for the use of the open questionnaire as to whether it was able to measure, describe, explain and theorise what it was intended (Long & Johnson, 2000). The use of an open-ended questionnaire ought "to collect contextual information for facilitating the interpretation of qualitative data" (Onwuegbuzie & Johnson, 2006, p. 53). Data collected from an open-ended questionnaire yields broad viewpoints. Considering that all the Grade 8 learners participated in the open-ended questionnaire, this ensured rich and thick descriptions that can provide details to support how information can be organised and analysed for interpretation (Teddlie & Tashakkori, 2009). In turn, results can become more realistic which can add to the validity of the study (Creswell, 2009).

The participants could not have directly provided responses to answer the research questions or confirm any hypothesis from the open-ended questionnaire. In other words, participants provided concentrated information deemed necessary to subjectively explore different meanings (Creswell *et al*., 2011). Cohen *et al.* (2011) argue that a wide distance between methods of data collection and research questions encourages honest cooperation from participants. In an effort to improve truthfulness of the data, the open-ended questionnaire was followed by the use of the Likert-scale questionnaire and the interviews. Moreover, it was communicated to the participants that their views from open questions were to be followed by other instruments for data collection. This prepared participants to be aware of what was coming next and allowed them to reflect on their understanding of statements they provided (McMillan & Schumacher, 2006).

Quantitative validity (The Likert-scale questionnaire)

Quantitative validation is taken to imply "the degree to which an instrument measures what it is intended to measure" (Long & Johnson, 2000, p. 31). The instrument was intended to fairly cover the domain of learners' views with the same weight as the major themes obtained from the open-ended questionnaire. In developing the Likert-scale questionnaire, each statement from individuals within the major themes had an equal probability because of its randomised selection. For Cohen *et al.* (2011), this form of validity demonstrates that the instrument comprehensively covers the items that it purports to cover is known as the 'content validity'.

Punch (2009) described internal validity to look at the extent to which the items are correlating with each other. As noted, two dimensions emerged after extraction for analysis using exploratory factor analysis. In one dimension the Cronbach alpha was 0.72, and in another dimension it was 0.88. In both cases, the scores were reliable. What constitute marginally or unacceptable low reliability is a coefficient alpha below 0.60 (Cohen *et al.,* 2011). In fact, the two extracted dimensions in the study were accepted for further exploration because of their reliability (Field, 2009). A coefficient alpha calculates an average of all possible split-half reliability (Cohen *et al.* 2011). Also, it can be noted that the relatively high average of all the inter-item correlation yields a high reliable measure (Field, 2009).

Validity is further understood as a judgement of the appropriateness of a measure for specific decisions that result from the scores (McMillan & Schumacher, 2006). In mixed methods research, it was significant to understand the role of quantitative analysis from the notion that it was also intended to expand data for further methods of data collection (Onwuegbuzie & Johnson, 2006). The results from the Likert-scale quantitative informed the

subgroups which were necessary to select as participants for the interviews. As much as qualitative research values each participant (McMillan & Schumacher, 1993), given many challenges of interviewing a larger population, it was necessary for the study to stratified purposefully in sampling key informants who have special status that can be shared for the trustworthiness of the research (McMillan & Schumacher, 2010).

Qualitative validity (The interviews)

Face-to-face verbal interviews were conducted in this study. Each learner was interviewed separately. Considering that the interviews were the third phase of data collection, participants were familiar with the faces of the researchers at that time, and that promoted the characteristics of prolonged engagements and social conversations (Long & Johnson, 2000). Prolonged engagements are commended to build trust and the natural bound between the researcher and participants (McMillan & Schumacher, 2006). Moreover, the researchers treated participants with respect and empathy to maintain mutual objectives of the research (Davies & Dodd, 2002). For example, the interviewers were careful not to interrupt participants during interviews.

In order to enhance validity, the researchers made attempts to reduce bias (i.e. a systemic tendency to make errors in the same direction) during interviews (Cohen *et al.,* 1994). Interviewers have different interactive styles (McMillan & Schumacher, 2010). Each researcher brings along some degree of biasness to the interviewing processes (Creswell, 2009). For instance, if the interviewer has a soft voice or a different accent, respondents can struggle to hear all the words, and opt to assume the meaning of the questions. Cohen *et al.* (2011) suggest that the interviews can be scheduled in a way to allow different researchers to contribute their different interviewing styles. In this study, three interviewers collected data. It was one masters student (me), one doctoral student, and the senior lecturer. The senior lecturer also provided guidance in planning and carrying out the interviewing processes.

Punch (2009) maintains that interviews are a good way of accessing people's perceptions, meanings of situations and constructions of reality. As already stated, this study used semi-structured interviews with an intention to examine learners' views in more detail whilst expanding data from the open-ended questionnaire instrument. The same structure of open questions was used for the interviews as the open-ended questionnaire. Statements from the open-ended questionnaire informed the development of the Likert-scale questionnaire. As such, the use of the interviews was valid when compared to the validity effects obtained from the Likert-scale questionnaire and the open-ended questionnaire. The matching of two or more measures is known as 'convergent validity'. Hence, it can be assumed that the

validity of the interviews was comparable with the proven validity of the other measures (Cohen *et al.,* 2011).

3.4.2 Reliability

Another essential concept for rigour in research is reliability. Reliability can be described as the consistency of a measuring instrument (McMillan & Schumacher, 2006). In general, reliability can suffer if different instruments used to collect data are administered at the same time (McMillan, 2012). In this study, learners participated in three sequential processes for data collection. Each measuring instrument was administered separately to keep learners motivated in order to enhance reliability. Below I begin by discussing the impact of the qualitative methods (i.e. the open-ended questionnaire and the interviews) to account for reliability.

Qualitative reliability (The open-ended questionnaire and the interviews)

In the nature of active involvement of the researcher, Guba and Lincoln (1985), cited in Punch (2009), extended the concept of reliability and looked at the "consistency over time (or stability)" (p. 244). One aspect of dealing with consistency over time is to give the same test to the same participants, under the same circumstances, but at a different time, and assess if the scores would correlate (McMillan & Schumacher, 2006). In this research, the open-ended questionnaire was used and later the participants were interviewed. This embodied the level of repeatability of results (Cohen *et al.,* 2011).

The other common sources of bias that may have effect on reliability can be associated with the personal conditions such as lack of motivation, mood, fatigue, and so on (McMillan, 2012). In this research, the participants took 15 minutes at most to fill the open-ended questionnaire. Also, the interviews took about 10 minutes per participant. The durations were deemed short enough to keep the learners motivated and relatively less stressed to participate in the data collections.

Quantitative reliability (The Likert-scale questionnaire)

Punch (2009) asserted that consistency over time can be directly assessed by parallel forms of the instrument. This study utilised the sequential mixed methods design approach. Particularly the use of more than one instrument to collect data ensured that if the Likert-scale questionnaire was valid and reliable, and there was general agreement with the Likert-scale questionnaire and the other instruments, then the other qualitative instruments were reliable. In this regard, McMillan and Schumacher (2010) refer to this technique as

'equivalence reliability'. The authors confirm that alternative forms can even be made up of different items; the scores attained by an individual would be about the same on each form. In this research, a 36-items Likert-scale questionnaire had similar responses to those that were offered by participants from the open-ended questionnaire. To a greater degree participants were familiar with the type of statement used, and according to McMillan (2012), this implies that reliability is therefore relatively free from errors.

3.4.3 Pilot testing the instruments

Two instruments were pilot tested in this research. Firstly, we piloted the open-ended questionnaire. Grade 9 learners within the same school were asked to participant in the pilot testing. For McMillan and Schumacher (1993), it is important to test if participants are able to understand the instructions of an instrument. In our case, learners were offered an opportunity to ask for clarity if they did not fully understand what was expected from them. Moreover, pilot testing a documented instrument can assist to identify whether a sequence of questions or any ambiguities in questions can lead to producing an irrelevant data (McMillan, 2012). Irrelevant data can be useless (Cohen *et al.,* 2011). Thus, pilot testing the instrument shed light on how learners identify with mathematics (McMillan & Schumacher, 2006). At the same time, pilot testing the open-ended questionnaire gave us an indication as to how long the targeted participants take to complete responding to the questions (Cohen *et al*. 2011).

Secondly, the interviews processes were pilot tested. One learner from the same group of learners that were going to be used in the study was interviewed. Again, time taken to participate in the interviewing processes was noted. This was essential for scheduling the entire interviews. In scheduling the interviews, the senior lecturer played a leading role in arranging suitable interviewing venues and to inform participants about dates and times. The other objective of pilot testing the interviews included a check for biases in the procedures, the interviewers, and the questions. During the pilot testing, we reflected on the procedures to identify clues that suggested that the participant were uncomfortable or did not understand the questions (McMillan & Schumacher, 2010). From the results, we slightly changed the order of questions to enhance clarity and to appreciate what had emerged from the pilot testing.

3.4.4 Ethical considerations

Learners that were selected to participant in this research study were minors under 18 years of age. The researchers were compelled to get informed consent from the government, the

school, the learners, and the learners' parents. When requesting informed consent, all facts about the project were communicated particularly to learners (and their parents), and decisions were left to the individuals if they wanted to participate or not. This study relied on the informed consent from the larger project. However, I also obtained ethical clearance from the Wits University Ethics Committee. The protocol number is 2017ECE006MR (see Appendix D).

An aspect of ethical principles in educational research includes taking into account that participants are somehow inconvenienced by their involvement in research studies (McMillan & Schumacher, 2010). In this research, learners were requested to sit in the classroom and respond to two sets of questionnaires. Each questionnaire took learners 15 minutes at most to complete. Also, some learners participated in the interviews and that took about another 10 minutes in order for participants to respond verbally to open-ended questions. Moreover, learners who were interviewed were audiotaped. These procedures may have intrusive elements (Cohen *at al.,* 2000) and carry some levels of discomfort, stress and anxiety for some learners as they are sharing their personal experiences and interpretations regarding mathematics. In order to offer learners control and free will, they were advised to withdraw their participation at any stage if they were feeling uncomfortable, exhausted or otherwise. At the same time, learners were assured that they were not going to be penalised or be disadvantage in anyway possible by not getting involved or withdrawing their participation from the project. McMillan and Schumacher (2010) asserted that "No one should be forced to participate in research" (p. 118).

In order to protect the privacy of participants, the following two practices were considered: (1) anonymity, and (2) confidentiality (McMillan & Schumacher, 2010). In all three stages of data collection, learners were assured that access to their characteristics, responses, behaviour, and other information was restricted to the involved researchers. In both the open-ended and closed questionnaires, the participants were required to provide their names. This stance ensured a systematic way of tracking learners throughout the project. The reason was that data analysis began before all the data was collected (Onwuegbuzie & Leech, 2004). On the other hand, we knew the names of learners that were selected for interviews. However, the names of the learners were not identifiable in any form of reporting in order to preserve anonymity, and this gesture was communicated clearly to participants and their parents.

With regard to confidentiality, we ensured that information from participants will only be accessible to the researchers that were involved with the project (Cohen *et al.,* 2011). In other words, we will never discuss or disclose any information to enable people outside the

project to have means of linking such information to participants' identities (McMillan & Schumacher, 2010). Another component of confidentiality required that all collected information from participants be stored in secured and controlled locations. That is, we have stored all soft copies in computers with personal security codes. Hard copies with information are also stored in locked cabinets. In five years after the research had been completed, all information will be destroyed. This means that we will delete all soft copies from the computers and their extended memories, and we will shred hard copies. Whilst this section accounts for procedural ethics, researchers have a responsibility to consider how their research contents, methods and reporting abide by ethical principles and rigour (Cohen *et al.,* 2011).

3.5 Summary

A mixed methods research approach was employed to frame the methodological research design of the study. The rationale of employing mixed methods research approaches appropriated the selection of the sequential mixed design. The sequential mixed design permitted the integration of both post-positivist and constructivist explanations while being guided by pragmatic philosophical worldviews in order to answer the research questions. The study further provided details of how learners participated during the collection of data for analysis. Data sets were collected in three phases. All Grade 8 learners participated in filling the open-ended and closed questionnaires, whilst six learners were purposeful stratified to participate in the interviews. Lastly, the study discussed validity, reliability, and ethical considerations to account for the quality and rigour of the study. The next chapter concentrates on reporting and processing the results obtained during data analysis from this chapter.

CHAPTER 4

REPORTING OF THE RESULTS

4.1 Introduction

This chapter presents the results obtained in both the qualitative and quantitative processes of the study. Given the objective of the research which sought to explore learners' identities in mathematics, the results are reported and analysed in three sequential phases to allow further consistent interpretations and discussions. The results are reported with separate headings for each phase, but there was a need to consolidate the data analyses because each phase of data collection entailed elements which directly influenced other phases of the investigation.

4.2 Results from the open-ended questionnaire

In the first statement, where learners were asked to describe their experiences of learning mathematics when they were in primary school, the following themes were extrapolated from their responses: understanding, resources and unclear. The context of themes was generally generated around the level of difficulty in learning mathematics. For example, learners were inclined to have experienced the learning of mathematics as being easy because of help they received from teachers in order for them to understand different concepts. The levels of difficulty in learning mathematics from the participants' past experiences were demonstrated to be trivial for the exploration of learners' identities. Instead, as indicated in Chapter 3, the focus was on justifications or reasons why mathematics was difficult for learners. The major theme was the 'understanding' of mathematics, and was raised by 68% of the learners. What further constituted the major theme was the context which entailed aspects of 'knowing' or 'unforgettable'. The dominant reasons for describing mathematics as being understandable were that pupils learned mathematics using smaller numbers and concentrated on fewer mathematical operations such as addition and subtraction in primary school.

Table 4.1 below provides a summary of themes obtained from statement one of the open-ended questionnaire. As shown in the table, themes are matched to two columns. The first column, named 'reasons or justifications', indicates the central reasons of how a theme came about. The second column, named 'factors of identity', provides a list of dominated words that brought about factors of identity which portray emotional reactions experienced by learners. For example, learners in the 'understanding' theme stated that when smaller numbers are used in learning mathematics, the subject becomes interesting, enjoyable or

likeable. The notion of ‘factors of identity’ is further exemplified in the ‘results of interviews’ section, and is also used in context to answer the first research question.

Table 4.1: List of themes from statement one and their related pronouncements

Themes	**Reasons or justifications**	**Factors of identity**
Understanding (68%)*	- Smaller numbers were used when learning mathematics. - Fewer mathematical operations such as addition and subtraction were utilised in learning of mathematics.	Fun, enjoyable, likeable, interesting, and exciting.
Resources (24%)	- Mathematical concepts were new to learners, and concrete teaching tools supported their learning. - Teachers played an important role to help learners pass the subject.	Helpful, logical, necessary, favourite, basic, and simple.
Unclear (8%)	- Mathematics was easier. - Mathematics was hard.	Nice, boring, and painful.

The second theme from statement one was called ‘resources’. The learners found mathematics to be manageable because of the application of teaching and learning resources. The learners found mathematics to be a challenging or puzzling subject although they managed to pass it. The common attribute shared by the learners in this theme was that mathematics was introduced formally to them for the first time, and that is why mathematics was a challenging subject. The theme received 24% from the learners who suggested that their learning of mathematics was dependent on teaching aids. The learners relied on concrete learning tools such as an abacus and sticks to count. One learner stated: “I was able to pass mathematics as long as I had my fingers”. On the other hand, many other learners claimed that the help of their teachers and parents was necessary for them to pass the subject. A sense of collaborative learning also surfaced when learners appreciated support from each other. These learners occasionally used plural pronouns such as ‘we’ and ‘us’ when sharing their past experiences.

The other 8% of views of learners remained in the context of different levels of difficulty. Some learners perceived mathematics as being an easy subject, but they provided insufficient reasons to justify their assertions. For instance, the learners stated that mathematics was understandable because it was easy or mathematics was manageable because it was not difficult. In other instances, the learners compared their past experiences

with their current experiences of learning mathematics. For example, learners would state that mathematics was easy in the past because it is difficult now. Learners in this theme were characterised as being ‘unclear’ about their views of learning mathematics.

In the second statement, learners were describing their experiences of doing mathematics at the present moment. The learners generally described the present moment of doing mathematics to be gradually becoming harder when they were comparing their experiences with those of the past. The learners indicated that mathematics is a ‘bit’ tough, difficult, confusing, or complicated at the moment because of the introduction of variables when solving algebraic equations. Again, the focus was on the reasons why learners find mathematics to be harder at the moment. The following three themes were presented from responses based on this statement, namely: understanding, resources and motivation.

The majority of learners (62%) stated that, as much as mathematics was getting a bit harder or challenging, they were managing, mainly because they understood what was explained to them in the classroom. The language used by the learners in this theme was that they could manage to ‘figure out’ what was required from them. Yet, these learners seemed to be in agreement that they still needed to focus more in class in order to pass the subject with good grades. One learner wrote: “Maths seems like a tough subject but if you put your mind to it, it can be the most easiest subject”. This can be linked to the kind of motivation learners envisaged to pass the grades. Moreover, the learners suggested that they need to practise more in order to be able to adequately understand and solve mathematical problems which demand long step-by-step methods.

The second theme from the second statement was named ‘resources’ and it represented 23% of learners’ views about the subject. In this theme, teachers, parents, and siblings were presented to have played important roles in assisting and supporting the learners to cope with challenges of mathematics. The learners praised the teacher for providing them with detailed explanations in his teaching methods. However, the detailed explanations did not give learners access to understanding new concepts in mathematics, but what emerged from the analysis was that the learners gained enough confidence to participate during classroom activities. Almost half of the learners in this group commended the teacher for permitting them to use calculators (and even calculators on their cellular phones) to workout different sums in mathematics. The learners also appreciated help from their parents for explaining some of the new concepts to make it easy for them to cope with difficulties of the subject.

The other group (15%) presented views whereby learners were comparing doing mathematics at the moment with when they were younger. Few learners in this group

stopped at only stating that mathematics is now harder when compared to before. A number of learners in this group expressed that they hate mathematics now because of all the rules that they are required to remember. The learners expressed being demotivated when they try to use the rules but still get most answers wrong at the end. As a result, they were no longer interested to learn the subject anymore.

Table 4.2 below, similarly to Table 4.1, shows the list of themes and a summary of justification provided by the learners in response to statement two. The table also listed some central reasons why a larger proportion of the learners felt that mathematics were bit challenging now when compared to when they were younger.

Table 4.2: List of themes from statement two and their related pronouncements

Themes	**Reasons or justifications**	**Factors of identity**
Understanding (62%)*	- The introduction of variables to solve algebraic equations required learners' understanding. - Learners have to cope with learning new things like Geometry.	Confusing, nervousness, pressured, interested, favourite, and enjoyment.
Resources (23%)	- The learners praised the help of the teacher and the support from parents to cope with challenges of the subject. - The used of calculators was important for the learners.	Helpful, necessary, and supportive.
Motivation (15%)	- Mathematics was confusing because of rules.	Boring, hate, painful, and hurtful.

In the third statement, four themes were drawn from the views of learners when they were describing their projections of doing mathematics when they get older. They were as follows: motivation, understanding, resources, and unclear. In general, learners responded by projecting that mathematics will be even harder in the future. About one third of learners (37%) indicated that they were motivated to continue with doing mathematics when they get to senior secondary school or higher learning institutions. The learners gave an impression that they have fewer options other than to concentrate and pass mathematics now in order to cope with grade 12 mathematics. The learners indicated that they are aware of the fact that mathematics was compulsory to them in the FET phase since they are attending a technical school. Also, the learners were motivated to pass mathematics in order to align

themselves with the career paths that they are inspired to choose when they get to attend universities and colleges. In this sense, a larger number of learners highlighted mathematics as a subject that is a pre-requisite to gaining competitive access to higher institutions of learning whilst standing a better chance of getting students' funding such as bursaries.

Table 4.3 below, similarly to Table 4.1 and Table 4.2, provides a summary of themes, their relative justifications and their emotional elements experienced by learners respectively.

Table 4.3: List of themes from statement three and the relative pronouncements

Themes	**Reasons or justifications**	**Factors of identity**
Motivation (37%)*	- Learners were motivated to study mathematics in order to align themselves with different career paths.	Inspired, motivated, encouraged, and compulsory.
Understanding (28%)	- Learners hoped that they will be familiar with the rules of mathematics.	Necessary, needed, enjoyable, and desirable.
Resources (9%)	- Learners predict that new and improved technology will assist them to progress when studying mathematics.	Helpful, and supportive.
Unclear (26%)	- Mathematics will be very hard or very easy.	Do not know or were not sure.

The second theme from the third statement presented how learners were intending to pass the subject. Views of the learners in this theme which was named 'understanding' received 28%. The learners believed that they must understand what they were doing in class in order for them to pass the subject. The language used by some learners in this theme included the fact that they needed to 'practise' or 'study' in order for them to understand mathematical concepts. There was also a sense that learners would get to understand mathematics because they would be familiar with 'steps and rules' used in the subject at that time. Also, some learners indicated that teachers would still be needed to explain different mathematical concepts even at university level.

A small number of learners (9%) predicted that mathematics would be easy in the future because of advancements in technology. Learners in this group claimed that new technology (computers, calculators, maths sets, and so forth) would bring about smarter ways of solving mathematical problems. In this way, mathematics would be embedded in their everyday life

experiences. However, there was an assertion from some of the learners that much of adjustment and "some getting used to" would be needed to accommodate new technology.

A group of learners who constituted views which formed the last theme received 26%. The theme was called 'unclear'. The learners stated that they were not clear or have no views other than to predict that learning mathematics will be much harder or much easier in the future.

4.3 Results from the Likert-scale questionnaire

The Likert-scale questionnaire had 36 items which were randomly developed from the major themes that had occurred from the open-ended questionnaire results. The major themes are indicated by stars (*) in the tables above, and they are: understanding, and motivation. The use of exploratory factor analysis (EFA) allowed the extraction of dimensions that emerged from the data. The following two dimensions emerged, namely: 'present views of doing maths' and 'past views of doing maths'. This means that there were relatively strong correlations of items in those two dimensions. In practical terms, for example, the learners shared a common consideration that 'Doing maths now is very understandable'. In another example, learners were consistent in their agreement with the following statement: 'I enjoyed doing maths when I was younger'. See Table 4.4 below for the summary of components of this analysis.

Table 4.4: Dimensions identified for identities of learners for analysis

Dimension identified	Number of items	Exemplar items	Cronbach α of resulting measure (reliability)	% Past / present / future
Present views of doing maths	7	I understand maths now; Maths at the moment is actually fun; Doing maths now is very understandable; and so forth.	0.88	100% present
Past views of doing maths	4	I managed to pass maths when I was younger; I enjoyed doing maths when I was younger; and so on.	0.72	100% past

In the table above, the last column, named '% Past/present/future', indicates the origins of grouped statements for the identified dimensions. For example, all seven statements in the

'present views of doing maths' dimension came from learners' experiences of doing mathematics at the present moment.

For further analysis, we then listed items of the two identified dimensions in Table 4.5. There were 11 items in total. In the 'present views of doing maths' dimension, one item was affecting the internal reliability for that group of items. The wording of the item was 'The more maths I do, the smarter I get'. This one item was removed to obtain the reliability of 0.88 otherwise the reliability would have been lower.

Table 4.5: List of items per identified dimension

	Dimensions	
	1	**2**
	Factor Type	Factor Type
I understand maths now.	Present	
Mathematics at the moment is actually fun.	Present	
Maths is now not difficult and I understand it better.	Present	
Maths is quite easy at the moment.	Present	
Doing maths now is very understandable.	Present	
Maths is now interesting for me and I would like to learn as much as I can about it.	Present	
Maths is easy now only if you follow instructions and concentrate.	Present	
Maths was fun when I was younger because we were using smaller numbers.		Past
Maths was easy when I was younger because it used basic operations (such as +, - , ÷ , and ×).		Past
I managed to pass maths when I was younger.		Past
I enjoyed doing maths when I was younger.		Past

To explore different perspectives about the two identified dimensions, we plotted them together using a scatter plot diagram (see Figure 4.1). This effort was to contribute to determining subgroups of different views from the learners' past experiences versus their present experiences of doing mathematics. A scatter plot diagram yielded three subgroups. Some learners have bad experiences of doing mathematics in the present whilst in the past they had good experiences. These two learners were positioned at the top left (TL) of the

diagram. Some learners had good experiences of doing mathematics in the past but not now, and these two learners were located at the bottom right (BR) of the diagram. The rest of the learners were scattered in a range where they had good experiences in the past as well as having good experiences now. These learners were located at the top right (TR) of the diagram. There were no learners that had a bad experience in the past and a bad experience now – i.e. there were no learners located at the bottom left (BL) of the diagram.

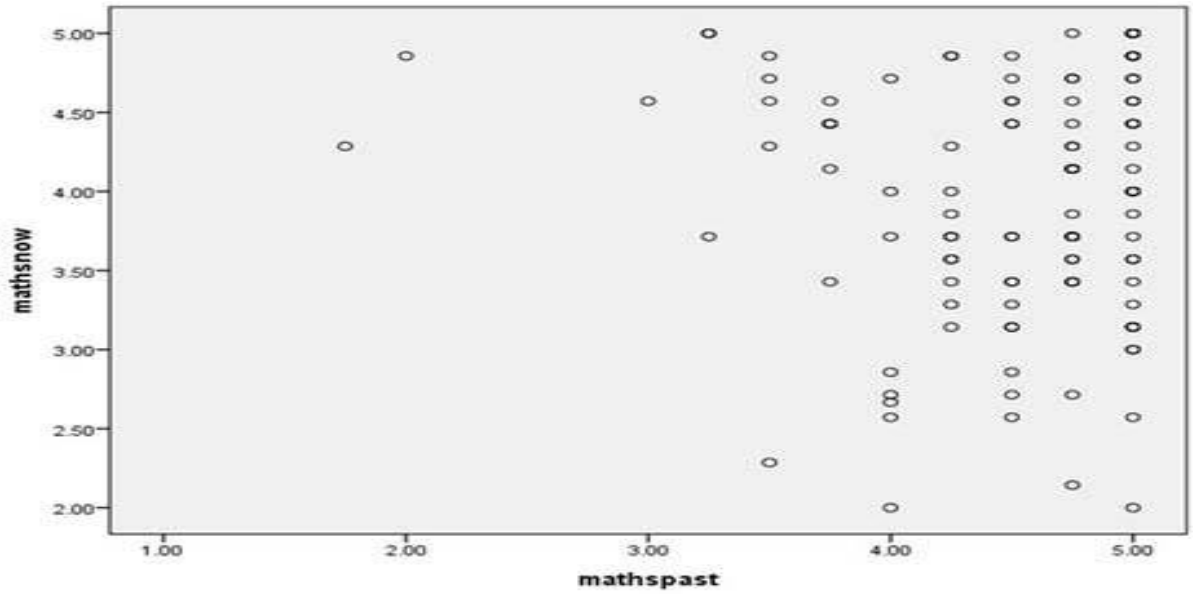


Figure 4.1: Scatter plot of the learners with the present views against the past views of doing maths

In the interest of getting to understand experiences shared by the learners from the two subgroups which did not conform to the majority views (the top left two and the bottom right two in Figure 4.1), there was a need to look particularly at their responses offered by each learner from the open-ended questionnaire. The comparison of the results between the Likert-scale and open-ended questionnaires became necessary for the complementarity purpose of the mixed methods research (Greene *et al*., 1989). We needed to confirm these learners' positions. Table 4.6 lists such comments made by the learners in the initial qualitative component when describing their experiences of doing mathematics in the past and in the present. Their future projections were not included as the focus was now on the comparison of the two emerged dimensions.

Table 4.6: Responses from the starred two subgroups

The bottom right learners	**The top left learners**
Describe doing maths when you were younger: - Maths was basic and fun when I was a young boy. - Maths was my favourite subject. It was easy if you listen and understand.	Describe doing maths when you were younger: - It was extremely difficult for me. I couldn't even tell time before. - Maths was very hard back when I was younger.
Describe doing maths at the moment: - Maths has become a challenge at the moment as I do not understand the equations and so on. - Maths is bit difficult now. I don't have a lot of interest in maths anymore because it's more complicated now and confusing. I also get very confused with the rules in maths.	Describe doing maths at the moment: - Math is suitable and easier at the moment. The more math I do, the smarter I get. - Maths is now not difficult, I understand it better.

In short, responses of the learners at the bottom right position had stated that mathematics was fun when they were younger because they understood the subject, but now they have lost interest in mathematics because of confusing rules and equations. The top left two learners acknowledged that they found mathematics to be 'extremely difficult' in the past, but they are able to understand the subject much better now.

4.4 Results from the interviews

The interviews were intended to interrogate the views shared by learners from their subgroups (at the BR, TL, and TR) for qualitative analysis. The first step in this section sought to discuss the three subgroups separately for analysis. The analysis concentrated on the three subcategories which were predetermined to contributing to answering the research questions, namely: factors of identity, pedagogy, and cause of change. The second step was to fit emotional reactions as factors of learners' identities about mathematics in the predetermined subcategories for analysis. These emotional identity factors were obtained from the major themes received from the open-ended questionnaire analysis. As indicated previously, the last columns in the tables (Table 4.1, Table 4.2, and Table 4.3 above) listed words which became what was labelled as factors of identity. Another example of such

identity factors was from the suggestion that learners have perceived mathematics to be understandable because they enjoyed doing the subject. From this exemplified outcome, we needed to direct questions to expand on what did the learners enjoy or did not enjoy about doing mathematics. As highlighted in the literature review, when learners enjoy the subject, they are transformed to realise what they can do to become certain individuals (Boaler, Wiliam & Zevenbergen, 2000). The last step of data analysis examined the views from the six interviewed learners to understand how learners can be supported to develop or improve identities in mathematics. Wenger's (1998) aspects of 'identity as practice' were used in all three steps of analysis. By framing the study in identity as practice, the researcher focuses on analysing cognitive and emotional reactions of the participants, with emphasis away from "models of ability" (Boaler *et al.,* 2000, p. 3) or what Darragh (2016) broadly described as a "performative identity" (p. 24).

4.4.1 The learners at the bottom right of the scatter plot

The two learners at the bottom right indicated that they had good experiences of doing mathematics in the past. The sources that influenced the identity of these learners were aligned with what they felt was expected from them by the school, besides the fact that the subject was easy because of the use of smaller numbers and the emphasis in using fewer mathematical operational symbols. At this stage, the learners did not confirm the findings from the other phases of the data analyses. The learners stated that they did not enjoy much about the learning of mathematics. When they were asked about what they enjoyed in doing mathematics in the past, these were their responses:

> Learner 1: In primary school, math was not too much; I enjoyed solving problems, I liked sum, and subtraction. I never enjoyed doing division. Multiplication – that is fine.
>
> Learners 16: I wouldn't say I enjoyed much about mathematics, but I know that it is a very compulsory subject; so I took it as a subject that I needed to do, so I didn't really much enjoy it.

Furthermore, the use of language in the quoted responses does not entail different ways that they could have engaged with other learners in the classroom. The responses indicate self-perceived roles by the learners. This is evident in the constant use of a pronoun "I" and the focus on different mathematical contents that they enjoyed (or did not enjoy) other than how such contents were taught or learned. The follow up questions were around the issue of how they were taught mathematics. Here were their responses:

> Learner 1: In primary school, the teachers always told us the rules and we did four or more activities in a specific rule; and the teachers explained more than once.

> Learner 16: They [the teachers] gave a textbook, they gave us an activity and they told us to read through that activity, and read through that chapter and complete the activity; and there were few sums which were written on the board.

There were indications from the quotes that the teachers used less time to explain classwork using the chalkboard. The learners used more time to do activities on their own. The fact that the learners concentrated on learning through textbooks and that they followed specific rules to complete activities from different chapters, in essence, such descriptions illustrate traditional teaching methods.

In sharing the experiences of doing mathematics at the moment, the learners indicated that they had lost interest in learning of mathematics. When the learners were asked to discuss what they were enjoying in Grade 8, again there was a sense of individuals' dedication when doing mathematics which involved less engagement with other learners other than expectations to interact with the teacher. On the other hand, the learners expressed that to not understand mathematical concepts limit them from participating in the classroom. The following quotes were the learners' responses:

> Learner 1: I enjoyed doing fractions in grade 8, but our teacher moves very fast so I can't really take notes because I need to take notes at the same time; and sometime, this makes it very difficult to understand.

> Learner 16: At this moment, I find it challenging because of my lack of asking the teachers in class. So the thing is that I don't interact much when I don't understand [laughing]. I think I am very shy.

The follow up question was about how they were taught mathematics at the moment. The learners emphasised that they were expected to remember different rules as they continue doing mathematics in Grade 8. The quote below gives the sense of applying a step by step approach when the teacher is explaining an activity to learners.

> Learner 1: The teacher says the rule once, we do one activity and then we move to the next step... I am struggling with my maths. I am struggling because I don't understand the rules, they are too much at once.

The learners' identity from this quote reflects the consequence of traditional teaching methods which sought to focus on reproducing knowledge from the provided rules, formulae, or concrete information. It also gives the sense that learners were expected to reproduce procedures without connecting them to everyday life concepts. The act of emphasising procedures without meaning has detriment effects towards developing learners' mathematical understanding (Brodie *et al*., 2009).

The last set of questions for this subgroup compared the experiences of learners when they were in primary school with that of the present moment. The questions sought to determine the causal effects of the change in their affective or cognitive reactions. Here are the questions: Has your view on maths changed from when you were younger to now? If so, what things have caused this change? Both learners agreed that their views have changed. The following response elaborates:

> Learner 16: They have changed. Well I would say the company, my determination and my commitment to school work; so that has really changed the whole perspective of math because now I have to take math seriously now. So I would say my views about math have changed a lot, then I wouldn't say math is a compulsory subject for me, but now they have changed.

So far the learners' identity in this subgroup could be summarised to have been influenced by an alignment mode of belonging. The learners concentrated on working out activities in the classroom because mathematics is a compulsory subject or they were following the teachers' instructions. In the last quote above, the learner brought elements of engaging with other learners as another reason that contributed to have changed his "whole perspective" and acknowledge to have started to "take math seriously now". In addition, the elements of self-determination and self-motivation have been credited to have contributed into these changes.

4.4.2 The learners at the top left of the scatter plot

The learners in this position had shared their cognitive responses about doing mathematics when they were in primary school. In their past experiences of engaging with mathematics, the learners had expressed that the subject was very challenging for them. In order to understand their emotional reactions, the learners were asked to respond to what they enjoyed the most and the least in doing mathematics. The learners pointed out that they did not enjoy the calculations which involved long divisions and multiplications procedures. One learner responded by stating the following when he was asked about what he enjoyed the most:

> Learner 8: Well, mathematics, I enjoyed that you could always, like, you could always get the answer. You could always make a right choice or a wrong choice but if you made something wrong, you could correct it.

The quote at this point gives an indication of how the learner engaged with mathematics to negotiate meaning. In the literature review, it was highlighted that a learner who have a positive "emotional engagement" (Santos & Barmby, 2010, p. 200) towards activities in the

classroom has acquired some effect of identity as *doing.* In other words, an individual is more likely to work across known and unknown without stressing about the correctness of single answers at the end of each activity. In the follow-up questions which were about how they were taught mathematics, the learners appreciated the importance of an experienced teacher. Experienced teachers are expected to know how to explain different concepts using sufficient examples whilst demonstrating that they know what they are doing. The following quote illustrates some of the dilemmas faced by learners with bad experiences of learning mathematics:

> Learner 13: They [the teachers] just teach us the same way they teach us now, but then she couldn't explain everything well because when I asked her, she would shout then I would ask another Sir who teaches me, he would not explain well. They are doing maths in grade six but they don't know what to do.

In the next segment, the learners are describing their experiences of doing mathematics at the present moment. The learners had expressed that they understand mathematics much better now. To determine affective responses in this subgroup, the learners were asked to share what they were enjoying about learning mathematics in grade 8. The continuation of how experienced teachers could add value by allowing learners to engage with other learners in the classroom came out again in this section. An experienced teacher manages small discussions that are taking place in the classroom. Moreover, an experience teacher stimulates mathematical discussions to continue even outside the classroom. The stated assertions followed from this quote:

> Learner 13: I understand it better. Because my Sir can explain it well when I go ask him. He tells me what to do and if I cannot understand him, I ask my friends because they understand better…

A role of the teacher has motivating effects on the enjoyment of learning mathematics. Motivating effects could reassure learners to work through long procedural algorithms whilst knowing that even if they get wrong answers, correct solutions are also attainable.

This last segment, similar to the other subgroup at the bottom right, sought to interrogate the cause of change from how the learners viewed mathematics in the past to how they view mathematics at the present moment. If there have been any changes, the learners were asked to described such changes. The learners agreed on the fact that they have experienced change in how they view mathematics at the moment when compared to before. One learner asserted that he has developed a much broader imagination of what the subject entails, and sees mathematics to have to do with "more things other than numbers". The other learner was quoted saying, "I am more focused now because last year if I didn't

understand, I will just leave it like that but now I make sure that I understand it". This quote illustrate that the learner has developed resilient attitudes toward engaging with teachers and other learners in order to cope with the challenges of the subject.

4.4.3 The learners at the top right of the scatter plot

The learners in this subgroup held the majority views. The learners had generally described the present moment of doing mathematics to be gradually becoming hard when they were comparing it to the past. For selection purposes, two learners from this group were chosen at random and they were interviewed. The idea was to move beyond the cognitive responses which were received from the open-ended questionnaire, and further interrogate emotional reactions. In this segment, we discuss the analysis of this subgroup from the similar sets of questions as the above two subgroups. The first question was, "What did you enjoy in primary school?" The learners referred to different contents to exemplify areas that they enjoyed or did not enjoy in their different schooling phases. For example, one learner would state that he enjoyed algebraic expressions, and another learner would state that she did not enjoy learning about shapes in geometry.

The follow-up set of questions was about how the learners were taught mathematics. It emerged that the learners were required to memorise rules. Learners tend to forget rules. This assertion is evident in the following quote:

> Learner 7: He showed us the… What is this rule? I forgot the rule. He showed us how we should use the rule and minus, plus, divided, subtract.
>
> Learner 12: They always make us do drills. They will start from level five – that you have to write a multiplication drill in five minutes. Then they change us into writing in four minutes and then the better you got the less time you get until you make it to level one which is very much impossible to reach – to write 50 questions in one minute. But some people were able to complete it.

During interviews on the same point of how learners were taught mathematics, one learner was unconsciously switching across formal school and after-school programs experiences. She relied on after-school programs' experiences to respond to her questions. According to this learner, after-school programs or weekend's camps assist learners with extra lessons. In her explanations, teachers in the after-school programs use informal mathematical language which assisted learners to remember rules. She explained that tutors of after-school programs use different teaching methods which include brainteasers, games and songs in order for learners to remember rules whilst they are having fun. Another learner in this

subgroup shared similar experiences but her sources of information about extra lessons were from watching learning channels on the television.

The learners shared similar descriptions of doing mathematics at the present moment in comparison to their primary school experiences. When they were asked about what they were enjoying now in junior secondary school, the learners reiterated that teaching and learning methods were not much different than those at primary school other that now they were required to remember even more rules. However, there were indications that learners enjoy doing mathematics when they are equipped with mechanisms to check if their own answers from working out activities are correct or wrong. The following response highlighted this point:

> Learner 12: …I don't like doing the triangle stuff but when it comes to solving for x I usually do that and you have to check it if is right or wrong. That's nice.

In the follow-up sets of questions which sought to determine how the learners were taught mathematics, the same sense of a teacher-centred approach emerged from their responses. Learners were expected to gain knowledge from textbook activities and as per teacher's explanations on the chalkboard. From this approach, one learner who passed the subject with a distinction gave credit to God. However, the learners recommended that teachers must be grounded in their subject knowledge. One learner reiterated that a teacher must "know what his doing" because "he can't teach what he doesn't understand".

The last segment was intended to determine the cause of change, if any, that learners have experienced between primary school and junior secondary school. The learners acknowledge that their views of learning mathematics have been narrow in the past. The learners have thought that mathematics was about "counting and stuff" but now they are aware of many career choices which can be achieved from studying the subject. The teacher was credited to have played an important role into ensuring that learners understand mathematics, and that mathematics was worthy to be studied despite the challenges. One learner was quoted saying, "now I understand everything… Sir is a brilliant man. He knows what he is doing". Within this sense, the learners were satisfied to be learning mathematics whilst aligning themselves towards different career choices.

4.4.4 The six interviewed learners

There were two questions which were asked with an intention to further contribute to the exploration of how learners can be motivated to develop or improve identities in mathematics. It was "What would your ideal mathematics classroom look like?", and "What

could people do to improve the way learners view mathematics?" For the first question, Boaler and Greeno (2000) have argued that suitable classroom environment encourage learners to fully participate in learning of mathematics. We anticipated both pedagogical and identification responses. The second question invited learners to share their experiences on how they can be engaged in order for them to participate in mathematics classrooms. Boaler, Wiliam and Zevenbergen (2000) used similar type of questions to investigate "the construction of identity in secondary mathematics education" (p. 3) in their study.

The learners appreciated to be in the classroom with posters on the walls. They described walls with posters to bring different colours to the classroom. The learners were convinced that posters must have mathematical examples that can help them remember the rules. Another learner suggested that learners can "sit around in a circle" and help each other with mathematics questions that they do not understand. This suggestion was connected to many responses which were offered by the learners with regard to the second question of how people can contribute to improving identity in mathematics. Moreover, the learners wanted teachers to provide clearer explanations in order for learners to understand mathematics better. It followed that teachers can use different ways to check if learners understand different mathematical concepts. This means that learners needed teachers to assess their understanding of mathematics.

Another suggestion was that teachers can provide extra lessons. In the extra lessons, it was reported that teachers can go over work covered in normal classes to ensure that learners who did not understand have another opportunity to understand rules of mathematics. A student had this to say:

> Learner 1: … like in English they have the rules, you must just follow the rules and you can get through anything; but I think the teacher should explain more than once because some learners really struggle… with math but I think the teacher should just do one rule maybe for two weeks so that they [the teachers] can explain it over and over again so that we could understand it properly.

The learners further pleaded with mathematics teachers to "bond more with learners" and not to "build walls" around them. The appeal was based on a general argument that mathematics teachers are not close enough to learners. A suggestion was that the teacher could talk more to learners like they are talking to their friends, particularly to those learners who are not participating in the classroom. One learner claimed that once learners are closer to a mathematics teacher, they rise to like mathematics more. Similar suggestions from this paragraph emerged in Boaler (2000b), and they were discussed in Chapter 2.

4.5 Summary

This chapter has presented the results of the study in three sequential phases. In the results from the open-ended questionnaire, learners' views about mathematics yielded themes which were discussed using texts and summarised in tables. Random statements from the major themes were used to develop the closed questionnaire. The results from the closed questionnaire were reduced to look at fewer variables using exploratory factor analysis. The notion of dealing with fewer variables assisted in stratifying learners for the purposes of the interviewing processes. Thus, at the end, this chapter reported the results from the interviews. Not all the results of the study were reported in this chapter. We looked at the results which sought to contribute directly to the means of responding to the research questions. The next chapter draws on the results and analysis presented in this chapter to answer the research questions and to relate the findings more to the existing literature.

CHAPTER 5

DISCUSSION OF THE RESULTS

5.1 Introduction

This chapter discusses the results that were reported and analysed in the previous chapter. The general findings about learners' identity open discussions to provide a background towards answering the research questions. Then, the results from all three research analyses (the open-ended, Likert-scale questionnaires, and interviews) are interpreted to contribute directly to answering the research questions alongside the relative literature. Thereafter, the research findings are explained whilst they are being compared to findings of other studies to account for the implications to teaching and learning practice. The last section discusses relationships between understanding, practice and identity to complement the implications of the findings to the practice, and further contribute in the development of theory for learner identity.

5.2 The general findings about learners' identity

The learners were consistent in indicating pedagogical connections between what they learned in primary school and junior secondary school. They identified with different levels of difficulty in doing mathematics as they gradually progressed within the schooling system. The learners were aware that content and context of each grade needed to show progression from simple to complex (DBE, 2011). The learners believed that mathematics 'was easy' in primary school, then it 'got hard' in Grade 8, and it will be 'even harder' going forward. Furthermore, the learners expressed continuous expectations that demanded clearer explanations in their quest for 'understanding' the subject. The notion of understanding became central in this study. Other findings from the analyses (resources, motivation, and unclear) contextualised how learners identified with mathematics, and likewise, they were carried over from primary school to secondary school.

The analysis of the Likert-scale questionnaire redirected this study to objectively give a focus to learners' views about their present and their past experiences. The analysis put forward an assumption that learners' mathematical identities were more coherent when they were examined within past and present experiences. The analysis therefore excluded the learners' thoughts, beliefs and attitudes about their future projections of learning mathematics. Learners' future inspirations of learning mathematics primarily depend on "making reality in the image of fantasies" (Sfard & Prusak. 2005, p. 19) and levels of imaginations can be widely different. It is also possible that a dimension about learners'

future inspirations did not emerge because fewer statements were used in the Likert-scale questionnaire.

5.3 Answering the research questions

Based on the context of general findings which emerged from all three phases (i.e. the open-ended questionnaire, Likert-scale questionnaire, and interviews) of data analyses and syntheses provided in the previous paragraphs, the study further discusses direct answers to each research question whilst illuminating deductions drawn from relevant findings of other studies.

5.3.1 What are the factors of learners' identities that emerge from Grade 8 mathematics classrooms?

The learners consistently required to receive clearer explanations from teachers in order for them to better understand different mathematical concepts in classrooms. The concept of understanding emerged strongly in both qualitative (thematic) and quantitative (numerical) analyses. The learners expressed that they become interested in doing mathematics if they understand different concepts. Mathematics becomes their favourite subject. Other emotional reactions which resonated from the concept of understanding mathematics included that the subject becomes fun, likeable, enjoyable, desirable, or exciting. On the other side, if they do not understand, the learners expressed that they feel pressured, confused, compelled, or nervous when doing mathematics. To illustrate these assertions, one learner was quoted as follows: "if I don't understand, I don't interact". Another learner was quoted as saying that she was struggling with activities because she does not understand the rules and different procedures of mathematics.

Parallel to emotional descriptions of understanding towards learning mathematics, the learners further explained their cognitive reactions. The learners needed teachers to use different and simpler methods to explain mathematical concepts. Firstly, by simpler methods, the learners meant that they were expecting to use short procedures when calculating in mathematics. The learners believed that using shorter procedures would enable them to arrive at correct answers quickly. Details of disadvantages of this position were discussed in the reviewed literature of this research. Furthermore, the learners expressed that they did not like or enjoy long division or multiplication because of its complicated procedural nature. Secondly, the learners used phrases like 'different teaching methods' and 'different examples' interchangeably. The learners described the use of different examples in mathematics as being different teaching methods. Thirdly, the teachers were expected to

remain in the same topics for longer in order for the learners to follow mathematical rules and not forget them. Barmby *et al.* (2007) cited Skemp (1976) who encapsulated these cognitive positions by classifying them as an 'instrumental understanding' of mathematics (p. 41).

Barmby *et al.* (2007) put forward an alternative definition of understanding from a variety of studies such as Skemp (1976), Nickerson (1985), Hiebert and Carpenter (1992), and Sierpinska (1994). For example, Skemp's (1976) contribution in defining relational understanding, which was "knowing what to do and why" (p. 2), was incorporated in Nickerson's (1985) description which required that learners get to see deeper characteristics of different mathematical concepts in relation to everyday life situations. The definition drew together ideas of "understanding being a network of internalised concepts with the clarification of understanding as an action and a result of an action" (Barmby *et al.,* 2007, p. 42). The reported results in the study do not demonstrate if the participated learners firmly identified with such inclusive explanations of the concept of understanding. However, the concept of understanding was important for learners when sharing their views and beliefs of doing mathematics in both their primary and secondary schooling experiences. The concept of understanding will further be discussed in the implications of findings to the practice – the next section. What follows below are the other findings from the thematic analyses (i.e. resources, motivation, and unclear) which form part of how learners identified with mathematics.

A second influential theme that emerged from the research was called 'resources'. It was about how the learners identified with roles of teachers in mathematics classrooms. The learners believed that inexperienced teachers are not adequately capable of teaching mathematics. From the analysis of the results, experienced teachers were described to be competent enough to explain different concepts or examples in great detail whilst building learners' confidence towards the subject. The 'Norms and Standards for Educators' describe the roles of teachers to include being specialists in mathematical concepts for a particular phase, and being specialists in teaching and learning practices (DoE, 2000). Grootenboer and Zevenbergen (2008) extend these descriptions by suggesting that the "teacher's role is to facilitate the development of students' mathematical identity by relationally bridging student and subject" (p. 243). In turn, there is a need for teachers to have a well-developed personal mathematical identity (Boaler, 2002).

In the statement of the problem to this study, there were claims that some teachers never abandon traditional teaching methods. The open-ended questionnaire and interviews analyses contributed to demonstrate how learners were taught mathematics in classrooms.

The analyses, particularly within the 'resources' theme, revealed that learners identified with mathematics from experiences where teachers were perceived as central sources of knowledge during the teaching and learning practice. Many learners believed that mathematical knowledge presented at school by teachers was new to them. This position contrasts with a suggestion that learners can "interpret what they see and hear on the basis of what they already know" (Brodie *et al.,* 2009, p. 19) in order for them to construct meaning (Wenger, 1998). The Curriculum and Assessment Policy Statement also encourages that teachers need to embrace active and critical approaches to learning from the socio-cultural perspectives of learners (DBE, 2011).

Furthermore, in the 'resources' theme, and given the fact that learner identity was viewed from the socio-cultural perspective, it was reported that many learners appreciated support from parents, peers and siblings. Other learners expressed their experiences of learning from the individualised dedications. Literature (for example Wenger, 1998) affirms that individuals are able to negotiate and make meaning from mathematics from their own social or cultural background. There were some learners, particularly during the interviews, who perceived the learning of mathematics from the natural identity perspective. However, the majority of learners returned to suggestions that the presence of teachers in classrooms enable them to be confident enough to work through long mathematical procedures. Teachers were commended for checking their class activities, but it was generally important for learners to be permitted to use calculators (even calculators on cellular phones) as a form of support when doing mathematics.

'Motivation' is another important dimension of identity that has emerged in the thematic analyses of this study. The effectiveness of motivation was analysed from the understanding of identity as *doing* (Wenger, 1998). The learners have displayed competence in mathematics, and their accountability to the classroom community. However, the reported findings were that the learners have demonstrated ego or performance goals. The phenomenon of ego or performance goals further emerged during the interviews. Githua (2013) refers to ego or performance goals to emanate from extrinsic motivation. Extrinsic motivation is a response to learners' external needs. The learners were motivated by external goals, which were more for the sake of passing tests or from the fear of failure. In the performance goals, learners are continuously stressing about "endless lists of isolated skills, concepts, rules and symbols" (Penlington, 2000, p. 22) to remember during assessments. This position narrowly characterised identity as *doing* where learners display competence merely because good grades in mathematics enable access to variety career choices. The learners did not adequately demonstrate inspirations of engaging in

mathematical activities, or demonstrate the importance of collaborative or explorative perspectives of learning.

An adverse side to identity as *doing* is that if these ego or performance goals are not achieved, learners embark on displaying other smaller goals such as being disruptive in class or refusing to complete assignments (Nasir, 2002). Nasir (2002) alluded to the importance of "achievement motivation" (p. 217), which yields long-term goals that are focused on how learners construct and negotiate mathematical knowledge in socio-cultural settings both in and out of school. Van de Walle (2004) refers to 'achievement motivation' as an 'inward motivation'. The author contends that 'relational understanding' yields 'inwardly motivated' mathematics learners.

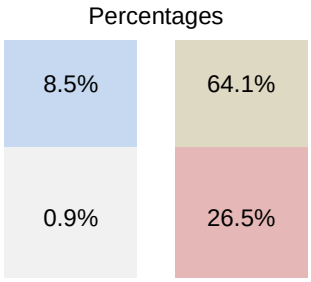
The responses in the fourth theme (which was called 'unclear') carried over from describing doing mathematics in primary school to describing mathematics in the future. Given that "we define who we are by where we have been and where we are going" (Wenger, 1998, p. 149), Grootenboer and Zevenbergen (2008) stated that learners' future participations in learning mathematics are significantly influenced by their previous experiences of learning mathematics. It was concerning that some learners in this research were unclear in defining how they see themselves as learners of mathematics. There are limitations that might have influenced such findings, and such characteristics will be discussed in the last chapter.

5.3.2 What caused the changes in learners' identities from when they were younger to now if there have been any changes?

A significant number of learners in the study were becoming negative in their identities. The quantitative analyses illustrated that learners' views of doing mathematics were negatively changing from when they were younger to now. A scatter plot (Table 4.5) in the reported results was refined to obtain the table below (Table 5.1). The refinement of Table 4.5 was intended to show how many learners had moved from positive experiences of learning mathematics to negative experiences. Before further explanations, it can be unsurprisingly observed that less than 1% of learners moved from being negative in the past to being further negative about doing mathematics now. Reasons for such change did not emerge in this study, but Gardee (2016), citing Graven and Buytenhuys (2010), explained that learners who experience mathematical 'abuse' in primary school give up on the subject as soon as they get a chance (p. 25). When looking at the diagonal end of the table for learners who move from being positive in the past to being positive now, 64.1% of learners were reported. Indeed, in general, literature confirms that positive experiences of doing mathematics in primary school contribute positively for current experiences (Gardee, 2016).

Table 5.1: Pre-measure of learners' views of doing mathematics

		mathspast				
		1.51 - 2.50	2.51 - 3.50	3.51 - 4.50	4.51+	Total
mathsnow	4.51+	1	6	8	22	37
	3.51 - 4.50	1	2	17	28	48
	2.51 - 3.50	0	0	16	12	28
	1.51 - 2.50	0	1	1	2	4
Total		2	9	42	64	117



8.5% of learners shared negative views of doing mathematics in the past, but moved to have more positive views in the present. During the interrogation of these learners, it was reported that although they had negative experiences with mathematics in the past, their relationships with the discipline of mathematics were strong. However, the subgroup of learners who moved from being positive in the past to being negative now was 26.5%. The difference between 26.5% and 8.5% indicates that more learners were becoming negative about doing mathematics. Hence, it was reported from using the numerical analyses that the mathematical identities of a significant number of learners who participated in this research shifted from being positive in primary school to being negative now.

The causal explanations for change in learners' mathematical identities were attained more from the qualitative analyses. For learners who had negative views about mathematics in the past, they described doing mathematics now to be more important than before. The learners acknowledged that when they were younger they saw mathematics to be a subject of merely numbers and counting. However, at the present moment, the learners recognised that passing mathematics, especially with good grades, increases their chances of better career choices. In secondary school, learners are exposed to a broader use of mathematics, and they are motivated to engage with other learners and teachers in the classroom community to align themselves with pre-requisitions of higher learning institutions (e.g. universities and colleges). Anderson (2007) points out that learners are aware that mathematics has become a gatekeeper to many educational and employment opportunities for adults. So for example, learners have understood that the learning of mathematics is an ultimate price to pay for pursuing careers in sciences and engineering sectors (Boaler *et al.,* 2000). Learners of mathematics have learned to strive to appreciate mathematical knowledge whilst developing resilient attitudes toward the subject.

Within this regard, reasons for change were further established from how learners were taught mathematics during the interviews. In the subgroup where learners have had bad

experiences in the past but they were having good experiences now, the findings demonstrate that the learners were exposed to teachers with strong personal mathematical identities. In addition, it was intriguing that these learners had described positive mathematical identity in the past but described mathematics to have been an “extremely difficult” subject for them.

For this subgroup of learners who described mathematics to have been “extremely difficult” in the past, but only became interested in mathematics now, the findings demonstrate that these learners had developed strong learner identity through open-ended and discussion-based orientated classrooms. This concern may not receive a satisfactory response here, and further research in the South African context may be needed, but according to Boaler (2002), some learners become reflective of their relationships with the discipline of mathematics. Thus, different teaching methods for such learners at a later stage, which could even mean traditional teaching methods, do not unsettle their developed relationships with the discipline (Boaler, 2002).

Learners who had good experiences of learning mathematics in the past but have lost interest in the subject now demonstrated little of what has changed and only trivial reasons why they have experienced such changes. However, such findings were discussed here as they provide important bases for implications of further research studies. The learners expressed that they were expected to remember rules and formulae in both primary school and secondary school. The learners felt that mathematical rules, formulae, and procedures were confusing and easily forgettable. In addition, they did not enjoy long mathematical procedures in both primary school and now.

However, in the problem statement, there were claims that some learners from traditional teaching practices could pass their examinations even with distinctions. To tie up this claim with those views of learners from the major group, Boaler (2002) confirmed that some learners come to like passive participation. These are the learners who have learned to position themselves as receivers of knowledge. They seek to faithfully reproduce procedures and follow clues that allow them to successfully work through tests and examinations (Boaler, 2002). To give one example, for many years in National Senior Certificate examination papers (i.e. South African grade 12 assessment), in algebra section of papers, learners are given a quadratic equation and asked to solve for ‘x’ correct to two decimal places. Learners who have learned to look for clues know that they have to use the quadratic formula to solve such an equation without wasting time searching for factors. Boaler (2002) argued that such learners remain extrinsically motivated in the mathematical community and do not begin to think about how or why some things are the way they are.

5.3.3 How can learners be supported to develop identities in mathematics?

It was highlighted in the literature review that learners enjoy doing mathematics if their classrooms employ integrated teaching approaches. Literature commended positive relationships between learners who enjoy doing mathematics and their capability to make sense of the subject. In this research, many learners avoided to identify with what they enjoy about learning mathematics. Many learners concentrated on pointing out different mathematical content that they liked or disliked. They did not discuss mathematics using cognitive terms – different ways of knowing or doing mathematics – which are elaborated in the mode of belonging as active engagement and participation. They preferred to discuss the importance of learning and passing the subject in order to align themselves with their potential career paths. In this regard, we concluded the same as the following assertion from Boaler *et al.* (2000):

> Most learners want to be successful at school, not least to avoid conflict with parents, but they also want to negotiate a way of being successful that does not alienate them from groups with whom they feel affinity (p. 10).

In essence, the learners wanted to carefully listen to the teacher, take notes, respond to the teacher's questions, ask questions for clarity in order to understand the explanations or ask for more examples to familiarise themselves with procedures, and then do their level best during assessments to pass the subject. The learners have come to accept that doing mathematics was "the suffering that cannot be avoided" (Geijsel & Meijers, 2005, p. 424). The learners were "detached from broader notions of identity" (Boaler *et al.,* 2000, p. 9). In short, the learners were displaying a resilient attitude towards what they think was expected from them by the schooling system and the society.

A second suggestion from some learners described aspects of collaborative learning. When reporting the results, the learners had imagined sitting around in a circle and helping each other with questions that they do not understand in the classroom. The findings demonstrated that learners believe in classroom-based discussions. However, many learners placed a teacher at the centre of discussions. A teacher would ask questions, and learners would discuss solutions amongst themselves in order to respond. In traditional teaching methods, Chauraya (2013) observed that teachers and learners communicate mainly by using questions and answers. This is because many teachers believe that if they ask questions and learners provide answers, learners are participating in the lesson (Brodie, 2007). Brodie (2007) argues that an in-depth consideration of "different kinds of questions and different interaction patterns" (p. 3) can be taken into account to develop learners' mathematical thinking in discussion-based classrooms. This author explored different kinds

of classroom dialogues for learner-centred interactions in mathematics classrooms, whereby she advocated for other forms of dialogues which take us beyond merely question-and-answers methods. Such dialogues will be discussed in the implications of the findings to the teaching and learning practice of mathematics.

Lastly, the learners suggested that teachers can provide extra lessons in order to improve mathematical success and develop positive ways of thinking about the subject. Some learners who have experienced after-school maths clubs reported that tutors from such programs use informal mathematical language which assisted them to remember rules of mathematics. This view was echoed by many other learners in the reported results. However, the learners believed that teachers in after-school programs should go over work covered in the regular classroom. Birmingham *et al.* (2005) suggest that after-school programs can develop a range of enriching learning opportunities with an emphasis on building positive relationships between learners and mathematics. This suggestion focuses less on helping learners with their classwork or homework. Rather, these programmes or clubs can aim to create new positive experiences and stories (Graven, 2011) that can contribute in developing learners' identity in mathematics whilst improving their mathematical knowledge and skills.

5.4 Implications of the findings to practice

In answering the research questions, the discussion of findings has focused on diagnosing, evaluating, and listing suggestions of what learners perceive to exist in the teaching and learning practice without elaborating further on 'how' or possible 'reasons and consequences' of such findings. When diagnosing the factors of learners' identity in mathematics, for example, the study firstly presented what the learners meant by understanding. The reported findings characterised learners to have described the concept of understanding more from the instrumental perspective. Secondly, the learners described the mathematics teacher as a source of knowledge. Lastly, the learners described discussion-based classrooms, and also put the teacher at the centre of discussions. In light of such descriptions and suggestions, this section incorporates the contents of findings from other studies to give a rounded picture of how the findings of this study may have implications to practice.

Carpenter and Lehrer (1999) propose five forms of mental activity that can be developed to promote teaching and learning mathematics with understanding in the classroom. There are: (a) Constructing relationships, (b) extending and applying mathematical knowledge, (c) reflecting about experiences, (d) articulating what one knows, and (e) making mathematical

knowledge one's own. These various forms of mental activity are interrelated and are integrated in the discussion below. Furthermore, the intention was to demonstrate how they link to the conceptual framework of this study in relation to the findings.

Learners construct meaning for a new idea or process by relating it to ideas or processes that they already understand (Carpenter & Lehrer, 1999). This assertion connects with Wenger's (1998) description of how people negotiate new meanings from their past experiences. Things take meaning from the ways they are connected to other things. For example, in some reported results of this study, the learners indicated that they enjoy solving algebraic equations. Learners used logical reasoning to solve a variety of problems involving finding the value of 'x' because it has room for guesswork, and it emerged in the results of the study that the learners themselves enjoy checking if their answers are correct or not. In general, and for this example, learners connect the concept of placing the missing number which was learned in primary school to solving for 'x' during formal algebraic concepts or in processes of symbol manipulation.

Carpenter and Lehrer (1999) also observed that developing understanding in mathematics involves more than simply connecting new knowledge to prior knowledge. The authors highlighted the need to construct rich and applicable mathematical knowledge. This suggests that school mathematics could be viewed as a human activity that reflects on finding out how and why given techniques work in solving mathematical problems (DoE, 2002). In Suh's (2007) study where she sought to change learners' disposition toward mathematics by focusing on understanding, the author would share with learners her personal real-life problems. For example, at some stage she shared how she used mathematics to build a playground set in their backyard which led into exploring measurement of area and perimeter, budgeting money, and comparing unit prices. Suh (2007) challenged learners to share their real-life experiences to pose problems in order for the class to utilise shared problems to engage them in formulating mathematical solutions.

Reflection involves the conscious examinations of learners' own actions and thoughts when doing mathematics (Wenger, 1998; Carpenter & Lehrer, 1999) which contrasts with merely assimilating procedures as they are explained to them. Reflective learning allows learners to navigate through a set of familiar and unfamiliar facts and concepts in order to make sense of mathematics (Kilpatrick *et al.,* 2001). Reflection provides learners with a chance to discuss their mathematical ideas, arguments, and justifications (Suh, 2007). It becomes central in understanding different mathematical concepts that promotes learner's ability to communicate or articulate one's ideas (Carpenter & Lehrer, 1999). In other words, articulation requires reflection, and Carpenter and Lehrer (1999) refers to articulation "as a

public form of reflection" (p. 22). Fennema and Romberg (1999) summarised these concepts by suggesting that "understanding is constructed, reflected on, and articulated by the learner and the knowledge that results is his or her own" (p. 187). Within the description of reflective learning, understanding of mathematics connects to the notion of identity. That is, learners identify with what the community of practice expect from them inside and outside the classroom.

Carpenter and Lehrer (1999) suggested that knowledge that has been learned with understanding plays an important role in solving unfamiliar problems. For example, junior secondary school covers different strategies for solving quadratic equations for a later stage of their syllabus. However, learners who have understood a concept of multiplying a number by itself (i.e. squaring a number) might solve the quadratic equation, say $2x^2 + 2 = 10$, by guessing numbers (in this case are -2 and 2) that can be multiplied by themselves, times two, plus two, to get the given answer ten, by connecting concepts and procedures from linear equations and can give arguments to explain their solutions. Kilpatrick *et al.* (2001) stated that such learners gain necessary confidence to move to another level of understanding.

A second reported identity factor was 'resources'. The learners identified teachers as their supreme source of mathematics. Indeed, teachers have a significant place in the classroom community. For Boaler *et al.* (2000), the 'old-timers' (teachers) through their actions and talk convey a sense of what it is to belong to the mathematics classroom community. In this case, the notion of actions and talk becomes more than perceived ways of how teachers present mathematical knowledge and skills to learners. In other words, mathematics becomes more than "an inert body of information and skills that teachers try to pass onto learners" (Grootenboer & Zevenbergen, 2008, p. 246). Boaler (2002) argued that teachers must themselves develop a personal mathematical identity, alongside their teaching experiences or mathematics understanding, which can include all learners and connections that are beyond the immediate classroom walls (Grootenboer & Zevenbergen, 2008). Adler (2001) encourages that the phenomenon of teachers as human resources can be realised from both 'noun and verb' characterisations, whereby in addition to basic issues of teachers' qualifications and their knowledge, teachers can play a supportive and mediating role in the classroom community.

Part of the reasons why learners view teachers as their main source of mathematical knowledge, and demonstrate insufficient connections between themselves and the subject, is generally because of the shortage of well-qualified mathematics in both the secondary and the primary school level. Grootenboer and Zevenbergen (2008) confirmed that more often

than not, mathematics classes are taught by non-specialist teachers especially in primary school, and so their commitment to mathematics is divided and that has negative consequences to their practice. Chauraya (2013) observed that some teachers have dual identities in South African schools. Some teachers get to teach more than one subject in schools, and according to Graven (2004), insufficiently qualified teachers of mathematics tend to lack the necessary confidence to fully participant in the practices of a community. This concern links to a point made earlier on in the problem statement which suggested that some students with strong potential to graduate in mathematics studies stop pursuing the subject, and for example, they venture into becoming teachers in other disciplines, but somehow find themselves returning to teach mathematics. Thus, every year, the schooling system creates a vicious cycle of producing fewer and ineffective teachers of mathematics (Grootenboer & Zevenbergen, 2008).

In describing effective teachers with a well-developed mathematical identity, Grootenboer and Zevenbergen (2008) suggested that they display authentic relationship between themselves and the subject. In this way, when learners are introduced to mathematics, they witness actions of something that has helped to define and transform lives of the old-timers (e.g. teachers). The learners must know why teachers value the subject. A sense of joy and satisfaction must shine from teachers when mediating relationships between learners and mathematics – learners' mathematical identities. Teachers themselves must have a strong mathematical identity. Chauraya (2013) described a strong mathematical identity to include, among other factors, love of the subject; enjoyment when teaching; positive attitude towards it; and self-perceptions such as dedication and commitment.

Another unexplained suggestion in the findings was about how learners perceive classroom-based discussions. The learners have put mathematics teachers at the centre of discussions. From learners' experiences of mathematics classroom, participation was more about answering teachers' questions. Part of the problem is that teachers tend to control learners' attention and behaviour by using question-and-answer as their teaching approach (Stiggins, 1992). In this approach, teachers randomly ask questions mostly when they intend to receive one-word or one-phrase responses. The questioning of learners becomes a classroom-management tool. An immediate solution to the problem is to encourage teachers to use and maintain more open-ended questions. When assessing learners in this way, learners may respond with proofs and justifications in their answers.

As previously indicated, Brodie (2007) explored this problem further within the South African context. The author placed an example of the traditional question-and-answers approach – questions with elicited one-word or one-phrase responses – at the centre and argued for

other kinds of interactions that support more genuine participation and thinking which included 'learner-learner dialogue' and 'whole-class dialogue'. In the learner-learner dialogue, a teacher poses questions to the class, and the learners challenge each other's reasoning through discussions to deepen their understanding of a mathematical concept. The discussions can allow learners to persuade each other in their thinking by interrogating each other's responses. At the end of the learner-learner dialogue, the learners themselves (and the teacher) confirm the correctness of the answer. In the whole-class dialogue, a learner can ask the teacher a question, and the teacher can redirect a question to allow the learners to respond to that question. The teacher may be central in the learners' discussions by making learners talk to each other. The teacher may also play a leading role in ensuring that learners' suggestions are not miscommunicated and that she or he can even repeats questions now and then when necessary. In both learner-learner and whole-class dialogues, it is important that teachers maintain the level of the cognitive demands of questions at all times, and not narrow questions or tasks demands to funnel learners to answers (Brodie, 2007). Another point that was encouraged in the study was that of authenticity of questions used in the classrooms. To elaborate on this point, Brodie (2007) was quoted as follows:

> 'Authentic questions' are questions which do not have pre-specified answers, which convey the teacher's interest in what learners think, and which serve to validate learner ideas and bring them into the lesson (p. 4).

'Authentic questions' are different from 'test questions' which seek to find out what learners know, and how closely their responses correspond to what the teacher requires (Nystrand *et al.,* 1997 as cited in Brodie, 2007, p. 4).

5.5 Relationships between understanding, practice and identity

The study answered the research questions from the learners' interpretations of their experiences of learning mathematics in the classrooms. The learners were reported to believe that they can succeed in knowing mathematics through understanding. When describing understanding, the learners were more concerned about remembering rules and using procedures in order to know different mathematical concepts. However, the learners described emotional aspects which match with the outcomes of relational understanding. The notion of relational understanding was discussed to elaborate on "understanding as the measure of the quality and quantity of connections that an idea has with existing ideas" (Penlington, 2000, p. 18). Thus, the findings about the learning (and somewhat teaching) of mathematics in the classrooms have led us to look at relationships between understanding, practice and identity as a theoretical relationship that needs development.

The findings of this present study extends Boaler's (2002) theoretical model (see Figure 5.1 below) of describing the relationships between knowledge, practice and identity by substituting 'knowledge' with 'understanding'. This study demonstrates that understanding yields certain kinds of knowledge that influences identity and practice. The notion of understanding can position learners as passive receivers or active producers of knowledge in the practice.

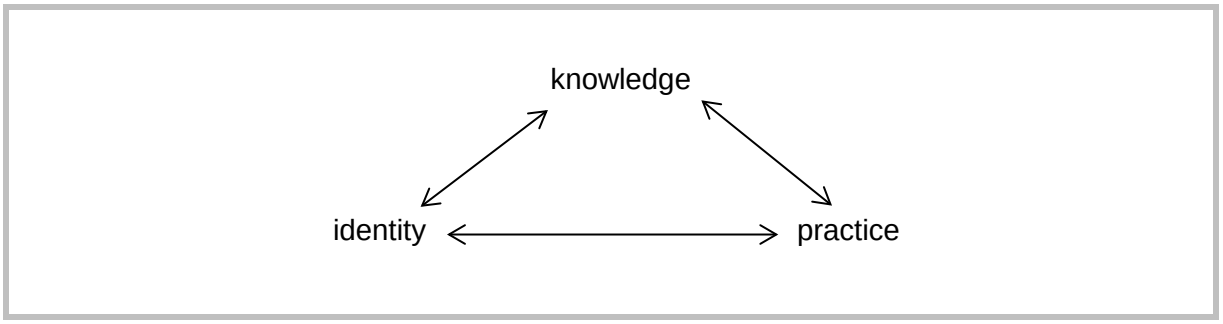


Figure 5.1: Relationships between knowledge, practice and identity (Boaler, 2002, p. 11)

The majority of learners in this study shared common views about the practice of learning mathematics. The findings also reported that many learners have not yet experienced a change of doing mathematics and how they identify with the subject. In light of these, the learners' past experiences from certain classroom practices influenced the kind of knowledge they have about mathematics, and their kind of knowledge limited identification. The learners who were unsure about their learning experiences within the classroom community (practice) became unclear about how they think of mathematics (cognitive effect), and then they could not adequately comprehend the description of how they think of themselves in relation to others and mathematics (identity). Hence, the findings of the study concur with the supposition that identities of learners and classroom practices are "mirror images of each other" (Wenger, 1998, p. 149).

How does understanding influence identity or practice? Literature (for example Barmby *et al.,* 2007; Grossman, 1986; Penlington, 2000) reveals that understanding depends on the existence of appropriate links between different concepts and the adaptation of new links. The greater the number of appropriate links to a network of ideas, the better the learner will understand. If 'instrumental understanding' and 'relational understanding' were placed across each other and allow learners' connections to exist along in a continuum, it will mean that learners who are towards the 'relational understanding' end have gained richer networks of related ideas, whilst on the other end, learners have 'loose linkages' in their ideas (Penlington, 2000). Van de Walle (2004) explained that nearly all learners situated towards the 'relational understanding' end enjoy learning mathematics. This is because new

information and new concepts that are presented find ways to connect with the learner's own ideas that have resonated from his or her background interactions (Boaler, 2002). Furthermore, relational understanding inspires a positive feeling, emotion (affective effects) in the learner of mathematics, as well as promoting a desire of knowing and reasoning (cognitive effects). Thus, as Van de Walle (2004) argued, through understanding, learners experience an 'inward motivation' to actively participate in classroom practices, whilst carrying along their relationships with mathematics.

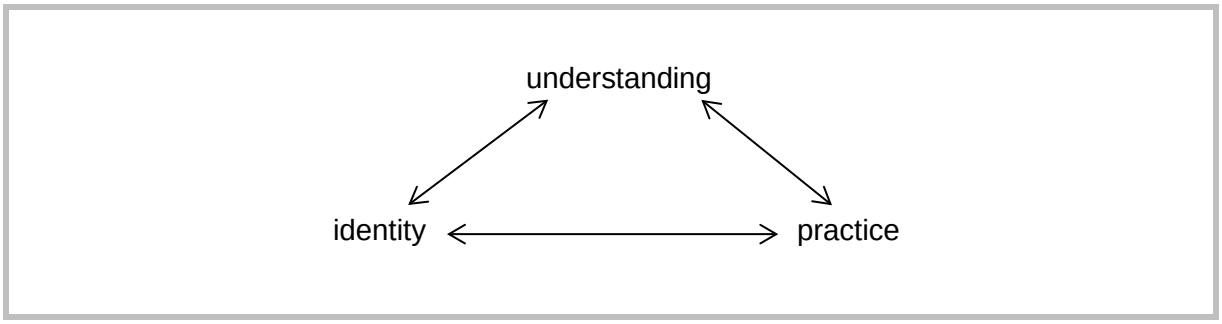


Figure 5.2: Relationships between understanding, practice and identity

Further research may be needed to evaluate inter-relationships between understanding, practice and identity (See Figure 5.2 above). A research can particularly link how a use of open-ended tasks in classroom practices can contribute directly to positive identities of learners in mathematics. However, an exploration of learners' identities in mathematics from the open-ended questionnaire as a first instrument when using mixed methods approaches has demonstrated that most learners prefer to understand mathematical concepts in order to positively identify with the subject. The notion of understanding therefore became pivotal for learners in their relationships with the discipline of mathematics and their learning practices.

5.6 Summary

The study analysed the learners' identities using identity as practice, particularly identity as *becoming* which encompasses identity as *negotiated experience* and identity as *doing,* and generally identity as *narrative.* Identity as *becoming* analyses describe learners' experiences (about themselves and mathematics) by examining classroom practices which include teachers' roles to project their future endeavours. Given that the results were not predicted at the start of the study, both qualitative and quantitative methods described the learners' pedagogical experiences from the emergent research design. The findings were synthesised and contextualised by drawing parallelises with findings from other studies for implications to the practice. The study concluded by putting forward that learners prefer to understand mathematical concepts in order for them to identify with the subject. The next concluding

chapter mainly discusses the implications of the findings for further studies whilst explaining factors that contributed to limitations of this study.

CHAPTER 6

CONCLUSIONS

6.1 Introduction

The limitations of the study are discussed in the first segment of this concluding chapter. This first segment focuses on different emphases of theories associated with Wenger's (1998) social theory of learning as relative frameworks when studying learners' identity in mathematics. The second segment deals with implications of findings for further research. In the last segment, the study presents a summary of the findings of this dissertation in the context of other studies.

6.2 Limitations of the study

The review of literature provided arguments about how learners can be influenced to develop positive identity in mathematics. The study used 'three modes of belonging' by Wenger (1998) as a theoretical foundation. At that stage, it had emerged that studying identities of learners proves to have a diversity of theoretical perspectives (Darragh, 2016; Sfard & Prusak, 2005). Studying learners' identities needed navigation around and refutation of certain issues when reporting the research. Mathematics education literature supports the steering among issues of learners' identities. However, the steering among issues limits research to explanations that are "away from other important foci that may have been considered in its place" (Darragh, 2016, p. 29).

Identity studies in mathematics education necessitate theoretical triangulation. Researchers (for example Chauraya, 2013; Klein, 2012, as cited in Darragh, 2016, p. 28; Lerseth, 2013) use more than one theory in their studies. As Denzin (1978) explained, cited in Johnson *et al.* (2007), theoretical triangulation implies that the researcher adopts more than one theoretical perspective to frame, explain, analyse and interpret different aspects of a study (p. 114). The following four enumerated segments of discussions elaborate on the theoretical limitations of the study while demonstrating links between intellectual traditions that can be emphasised or incorporated in further learners' identities studies which are intended to select Wenger's (1998) social theory of learning.

Firstly, this present study focused on exploring learners' identities from the emergent research design. A strong inclusion of other theories of social structures would have meant debating on issues without drawing parallels from the primary data to provide augmented discussions in the study. For example, Bourdieu (1986) provides in-depth theoretical tools

which encompasses solutions to debates of why some pedagogical practices are socially and culturally biased in contributing to stratified successes (and failures) of certain groups despite their direct attempts to become certain learners of mathematics (Atweh *et al.,* 2001). South Africa has diversified cultures and polarised social classes. The embodiment of cultures and social classes include a linguistic competence. Linguistic competence (or incompetence) determines the legitimacy of how learners participate in the mathematics classroom dialogic interactions (Zevenbergen, 2001).

Barwell (2009) conducted research in the United Kingdom and noted that learners from minority ethnic groups regard English as a second language. Similarly, in South Africa, particularly in rural and township schools, English is a second language for the majority of learners. However, English is used in mathematics classrooms as the formal language of teaching, textbooks and examinations. In the context of classrooms, learners use two or more languages to do mathematics (Setati & Adler, 2000). According to Boulet (2007), English becomes a barrier in learning mathematics where for instance certain concepts are understood (sometime with misconceptions and errors) and cannot be explained by learners during participation in classrooms. Pedagogic discourse from linguistic competence influences mathematical identity. For example, the emerged findings of this study depended on descriptions from conversations with learners about each other and their relationships with mathematics. In the reported findings, a small group of learners (on an average of 11%) were not sure about their experiences of doing mathematics in the past and about what to expect in their learning endeavours. Boulet (2007) explains that linguistic competence can limit learners' experiences of learning mathematics and their abilities to articulate what they have experienced during learning processes.

Secondly, theories of social structures particularly around cultural systems as highlighted above link directly to theories of identity which turn to compare issues of gender, class, ethnicity, and age. Given the intentions of this study to explore identities, it unvaryingly focused on analysing data for all Grade 8 learners in the mathematics classrooms. The participants' social classes and their ages in particular, and ethnicity in general, may constitute to be homogenous in terms of generalising the study, but gender groups from theories of identity have room to contribute in equity debates especially in the South African context. Mophosho (2013) points out that "the burden of history" (p. 92) which is often expected not to be a part of generations of younger female South Africans lived experiences is spoken of as present. Identity debates within a gender context can contribute to addressing disproportionality in numbers of women in certain career sectors such as sciences and engineering.

Thirdly, a minimal inclusion of theories of social practice, particularly those of social reproduction, poses another limitation for further research in identity. The study discussed two implications of the modern world when describing identity as *becoming*. First, it was about how the modern world position learners with certain fixed natural identities to have unfavourable relationships with mathematics. Second, it was stated that poor public schools tend to regenerate individuals that remain on the periphery of communities of practice. As much as schools serve as a vehicle to escape poverty and other inequalities for some learners, even though they are presented with mere access to learning mathematics, many learners are 'left behind'. In South Africa, researchers (for example Graven, 2015; Spaull & Kotze, 2015) point out that by the time learners from poorer schools get to grade 9, they will be as good as learners in grade 6 when compared to their peers in wealthier schools. This discrepancy will force learners to not advance in mathematics or some of them dropping out of school. Thus, other than to research identity from the 'theories of social practice' context, practical intervention strategies can be recommended for further research.

Lastly, an adequate elaboration on theories of situated experiences is important when researching learner identity in mathematics. Many researchers (for example Lave, 1988, Brown *et al.,* 1989; Lave & Wenger, 1991; Boaler, 2000a, 2000b, 2002) explained that situated perspectives on learning offer radical interpretations on how knowledge can be distributed between people and activities. Situated perspectives yield divergent positions from psychological perspectives which represent knowledge as an individual attribute. In this study, it was argued that practitioners from psychological perspectives on learning have began to recognise knowledge as being co-constructed by individuals and other people within the social context.

The problem statement of this study could have been expressed in the context of situated experiences which emphasise agency. Instead, the study considered modes of belonging (engagement, imagination and alignment) to be central in encouraging learners in mathematics. The study did not directly explore the effect of human agency. Rather, the study criticised traditional teaching approaches as a contributing factor in supressing positive learner identity, and consequently an underdeveloped identity will reduce agency (Boaler & Greeno, 2000). The assertions of learners dropping mathematics (as soon as they can) did not elaborate on many learners who decide to change schools, and sometimes be returned to lower grades, in order to change their experiences of learning and express their agency.

However, on the impact of situated perspectives, the study discussed in some detail learning processes as understood in the concept of 'cognitive apprenticeship' by Brown *et al.* (1989). In cognitive apprenticeship, the focus is to elaborate on why definitions, rules and

procedures are important when learning mathematics. The argument is that a manipulation of rules and procedures can be understood as mathematical tools or procedural fluency. This suggested that learners, equipped with mathematical tools, whilst knowing when and how to use them, can actively participate in mathematics classroom to develop different knowledge that they can use in different situations.

In addition, two other limitations were noted in the section on mixed methods research design. As previously stated in the rationale and elsewhere, using an open-ended questionnaire as a first step of data collection can be complex. The purpose behind an open-ended questionnaire encourages participants to express their views free from the subjectivity of the researchers. Researchers use theorised open questions from a certain conceptual framework to capture views of a particular content area. The open-ended questioning can have a wide gap between what is researched and the participants' responses which can lead to further complexity when collecting and analysing data. For that reason, open-ended questions may yield broad outcomes with a variety of connections, imprecisely directed at times towards the topic. In this research, the participants did not respond directly to relationships they have with mathematics. For instance, the learners stated what they think about mathematics from their beliefs. As much as beliefs form a part of identity (Sfard & Prusak, 2005), analyses of identity need not be limited to learners' perceived descriptions of mathematics, rather analyses further necessitate actual actions of how they respond to different practical situations during learning and teaching practice (Chauraya, 2013).

A final limitation came from the development of the Likert-scale questionnaire from the open-ended questionnaire. The data were collected and analysed in three sequential phases. Utilising the open-ended questionnaire was the first phase. The learners responded to three open statements – statement one required learners to share their experiences of learning mathematics in the past; statement two required learners' present experiences; and statement three required future projections of learners. For the development of the Likert-scale questionnaire, statements were randomly collected from the major themes that emerged from each statement of the open-ended questionnaire. The weighting of random statements carried over from the open-ended questionnaire to the Likert-scale questionnaire was equal. In a total number of 36 random statements, 15 statements were from 'understand in statement one' which formed 68% of learners' views, 14 statements from 'understanding in statement two' which formed 62% of learners' views, and 7 statements from 'motivation in statement three' which formed 37% learners' views. An argument will be that there were fewer statements from the major theme in statement three of the open-ended questionnaire that were carried over to form part of the Likert-scale questionnaire, and as a result, views of learners about their future projections did not emerge strong from the exploratory factor

analysis of the Likert-scale questionnaire. Instead, if equal number of random statements (12 statements per the major theme) were used, presumably a third dimension about learners' future projections might emerge more strongly. Going forward, other studies can experiment with these contested technical strategies to validate (or dispute) such logical arguments.

6.3 Implications of the findings for further research

The learners shared more of their experiences of learning mathematics from their past (primary school) and elsewhere (extra mathematics lessons). Data collection in this study started during the second term (April) of school, and it was collected from Grade 8 learners. Data collection instruments required learners to share their experiences from when they were younger (which implied primary school) to now (which implied junior secondary school), and their future projections (e.g. universities or workplace). Hence, keeping in mind that the learners have spent many years in primary school, the findings of this study can be read with an understanding that they did not have adequate experiences of secondary school.

Barnes (2004) documented that a significant number of learners in South African urban areas attend some form of extra mathematics lessons. The author recorded an average of 41% of junior secondary school learners that attend extra tutorials in urban areas. Graven (2011, 2015) reported on the after-school mathematics clubs that are rolled out for learners in rural schools as a learning intervention strategy. The reasons for attending extra mathematics lessons included an 'improvement of the results', 'understanding the work done in class' (Barnes, 2004), 'strengthening learning dispositions', and 'creating positive learners' identities' (Graven, 2015). Learners who have experienced extra mathematics lessons outside of school hours also emerged in this study. As such, further research can interrogate an impact of extra mathematics lessons when exploring learners' identity from the regular mathematics classrooms.

6.4 Summary of the findings

The study avoided debates around the notion of natural identities and performance abilities of learners. It relied on deductions which advocate that every learner has a potential to succeed at learning mathematics. The focal lens of studying learners' identities in mathematics zoomed out to look at learning from its sociocultural context, and zoomed in to explore learners' relationships with mathematics (Darragh, 2016). The study was framed in Wenger's (1998) broader social theory of learning. It concentrated on what Darragh (2016) characterised as "participative identity" (p. 24). Participative identity looks at the ways in

which identity is constructed through participation and engagement in social groups (Darragh, 2016).

Thus, in the literature review, the study discussed the development of positive learners' identity in mathematics through three modes of belonging (engagement, imagination and alignment) to a community of practice. In other words, positive learners' identity in mathematics implied that learners can be encouraged to engage with different mathematical concepts in order to adapt to procedures, and knowledge through understanding when offered in the classroom. And through imagination and alignment, learners can be motivated to develop positive relationships with mathematics. In this study, the majority of learners have generally accepted that mathematics will remain part of their lives as long as they are still attending school or still have intentions of advancing their studies. Thus, the first set of findings about positive learners' identity generally meant that the learners were continuously striving to belong to a mathematics community through engagement, imagination and alignment.

In the second set of findings, when listing factors of identity, the concept of understanding emerged strongly in the study as a product of clearer explanations from the mathematics teachers. When their understanding of the concept was analysed, it emerged that learners needed teachers of mathematics to remain longer in one section in order for them to not forget the rules and procedures or they needed teachers to explain using many examples on the board. They described the concept of understanding more from the instrumental perspective.

The problem with instrumental understanding is that learners become performance driven. The notion of motivation was discussed in this study. The learners were reported to concentrate on passing grades with good marks and moving on to the next class. The learners needed to be seen as being competent in the classroom. Extrinsic motivation limits learners to short-term goals that needed to be achieved at the present moment. On the other hand, literature reveals that learners with relational understanding obtain inward motivation, or what Nasir (2002) described as 'achievement motivation', which allow sense of reflection during mutual engagement with other learners when doing mathematics. In turn, learners who are inwardly motivated can align themselves towards the mathematical careers.

In the third set of findings, the quantitative analyses confirmed that a significant number of learners were becoming negative in their identities. The study discussed reasons for change highlighting the analyses from two subgroups. The minority of learners talked more about their relationships with mathematics. This subgroup also deliberated on the fact that it was important to understand mathematics. This subgroup also highlighted the significance of a

mathematics teacher who equips learners with different learning methods which included techniques of checking their own answers or a teacher who is able to verify if what learners are doing in the classroom make sense. Along similar lines to the processes of justifying mathematical concepts and proofs, the learners were happy to receive timeous feedback from a teacher.

When the minority subgroup were describing doing mathematics, it was more about how they were at learning the subject. These learners used content areas of mathematics as examples to elaborate on how they were like at learning mathematics. When they were asked about what did they enjoy or like in learning mathematics, it was more about engaging with the subject to negotiate meaning. They emphasised that it was enjoyable knowing that one could get correct answers once he or she had made a right choice or redeem oneself if he or she got wrong answers by seeking alternative methods. Burton (1999a) has asserted that learners must have resilient feeling of knowing that a path towards getting a correct solution exists. It was further clear from the discussions with this small group that collaborative learning was necessary. One learner stated that, if she did not understand the explanations from the teacher, she would ask her peers for further explanations. These learners in this minority group demonstrated envisioned learners' identity in mathematics.

The other subgroup demonstrated little of what has changed and only trivial reasons why they have experienced such changes. The learners expressed that they were expected to remember rules and formulae in both primary school and secondary school. The learners felt that mathematical rules, formulae, and procedures were confusing and easily forgettable. These learners were noted to want to carefully listen to the teacher, take notes, respond to the teacher's questions, ask questions for clarity in order to understand the explanations or ask for more examples to familiarise themselves with procedures, and then do their level best during assessments to pass the subject.

The last set of findings focused on how learners can be supported to develop their identities in mathematics. The learners suggested that teachers can provide extra lessons in order to improve mathematical success. The learners believed that teachers during extra lessons should go over work covered in the regular classroom. However, Birmingham *et al.* (2005) suggest that after-school programs can develop a range of enriching learning opportunities with an emphasis on building positive relationships between learners and mathematics. This suggestion focuses less on helping learners with their classwork or homework. Rather, these programmes or clubs can aim to create new positive experiences and stories (Graven, 2011) that can contribute in developing learners' identity in mathematics whilst improving their mathematical knowledge and skills.

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APPENDIX A

Your views of mathematics

NAME ……. SURNAME…….....

CLASS ……..

We need your name just in case we want to further follow up some of your comments, but otherwise what you write will remain completely anonymous.

Please write two or three sentences for each of the following question.

Describe doing maths when you were younger:

Describe doing maths at the moment:

Describe doing maths when you get older:

APPENDIX B

NAME…… SURNAME……

Please tick one box for each statement to show your level of agreement

		Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
1	Maths was easy when I was younger because it used basic operations (such as +, - , ÷ and ×).	☐SA	☐A	☐N	☐D	☐SD
2	Maths is quite easy now and it needs to be explained only once.	☐SA	☐A	☐N	☐D	☐SD
3	Maths will obviously get more difficult, confusing and complicated in the future.	☐SA	☐A	☐N	☐D	☐SD
4	Maths is a good thing to have in life.	☐SA	☐A	☐N	☐D	☐SD
5	Maths is now interesting for me and I would like to learn as much as I can about it.	☐SA	☐A	☐N	☐D	☐SD
6	In order for me to understand maths in the future I got to start learning it now.	☐SA	☐A	☐N	☐D	☐SD
7	Maths was fun when I was younger because we were using smaller numbers.	☐SA	☐A	☐N	☐D	☐SD
8	Maths is now a little bit hard and not understandable in some topics.	☐SA	☐A	☐N	☐D	☐SD
9	I see maths as challenging in the next few years.	☐SA	☐A	☐N	☐D	☐SD
10	My previous teacher explained until you understood so for me it was not hard.	☐SA	☐A	☐N	☐D	☐SD
11	Doing maths at the moment is difficult and some things are confusing like in algebra.	☐SA	☐A	☐N	☐D	☐SD
12	I will be using new and improved instruments to do maths in the future.	☐SA	☐A	☐N	☐D	☐SD
13	Maths was easy in the past because I used to work out sums with an abacus.	☐SA	☐A	☐N	☐D	☐SD
14	Doing maths now is very understandable.	☐SA	☐A	☐N	☐D	☐SD
15	I am willing to work harder at learning maths and get a distinction.	☐SA	☐A	☐N	☐D	☐SD
16	Maths used to be a challenging subject.	☐SA	☐A	☐N	☐D	☐SD
17	Maths is quite easy at the moment.	☐SA	☐A	☐N	☐D	☐SD

Please turn over the page

Please tick one box for each statement to show your level of agreement

		Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
18	I am going to use maths in my future career.	☐SA	☐A	☐N	☐D	☐SD
19	I managed to pass maths when I was younger.	☐SA	☐A	☐N	☐D	☐SD
20	Maths is now not difficult and I understand it better.	☐SA	☐A	☐N	☐D	☐SD
21	I will never stop doing maths because someday I could have my own business.	☐SA	☐A	☐N	☐D	☐SD
22	The teacher I used to have was helpful because he used to always explain over and over again.	☐SA	☐A	☐N	☐D	☐SD
23	I understand maths now.	☐SA	☐A	☐N	☐D	☐SD
24	I am hoping to get the best maths teacher in the future.	☐SA	☐A	☐N	☐D	☐SD
25	Maths was a bit difficult in the primary school.	☐SA	☐A	☐N	☐D	☐SD
26	For me, I find maths to be a subject that needs a lot of thinking and practising.	☐SA	☐A	☐N	☐D	☐SD
27	My everyday life will revolve around maths in the future.	☐SA	☐A	☐N	☐D	☐SD
28	Maths was bit difficult when I was younger.	☐SA	☐A	☐N	☐D	☐SD
29	Mathematics at the moment is actually fun.	☐SA	☐A	☐N	☐D	☐SD
30	I expect maths to be a lot harder in the future, but I know I'll pass it well once I've learned it.	☐SA	☐A	☐N	☐D	☐SD
31	I enjoyed doing maths when I was younger.	☐SA	☐A	☐N	☐D	☐SD
32	Maths is easy now only if you follow instructions and concentrate.	☐SA	☐A	☐N	☐D	☐SD
33	I currently hate maths because of the polygons (shapes) and the algebraic expressions.	☐SA	☐A	☐N	☐D	☐SD
34	I will have to learn with others to understand maths to make my future better.	☐SA	☐A	☐N	☐D	☐SD
35	The more maths I do, the smarter I get.	☐SA	☐A	☐N	☐D	☐SD
36	Maths is my favourite subject because without maths you can't pass the grade.	☐SA	☐A	☐N	☐D	☐SD

Thank you for completing this questionnaire.

APPENDIX C

Interview questions

1. What is your favorite subject in school? Why?
2. Please tell us about your experiences of doing math when you were in primary school.
    (a) What did you enjoy the most and the least?
    (b) Did you find math easy or difficult? Why?
    (c) How were you taught mathematics?
    (d) What were your teachers like?
3. Please tell us about your experiences of learning math in Grade 8.
    (a) What do you enjoy the most and the least?
    (b) Do you find math easy or difficult? Why?
    (c) How are you taught mathematics? What is your teacher like?
    (d) How useful is math for you at the moment?
    (e) Why are you struggling with math at the moment?
4. Has your view on math changed from when you were younger to now? If so, what things have caused this change?
5. Please tell us about your views on doing math when you get older.
    (a) Will math be important for you in the future?
6. What could people do to improve the way learners view doing mathematics?
    (a) What would your ideal math classroom look like?
    (b) What things could an after-school club do to improve learners' views of mathematics?
7. Thank you. That is all we wanted to ask. Is there anything else you would like to say about doing mathematics?

APPENDIX D

Wits School of Education



27 St Andrews Road, Parktown, Johannesburg, 2193 Private Bag 3, Wits 2050, South Africa. Tel: +27 11 717-3064 Fax: +27 11 717-3100 E-mail: enquiries@educ.wits.ac.za Website: www.wits.ac.za

6 April 2017

Student Number: 1167996

Protocol Number: 2017ECE006MR

Dear Wanda Masondo

Application for Ethics Clearance: Master of Education by Research

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate, has considered your application for ethics clearance for your proposal entitled:

Learners' identity in mathematics

The committee recently met and I am pleased to inform you that clearance was granted.

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely,

M Mabela

Wits School of Education

011 717-3416

cc Supervisor – Dr Patrick Barmby